Final Report Submitted to

Iowa Department of Natural Resources

Contract No. 03-7530-01

A Cost Analysis Study of the Benefits of Building Energy Code Upgrades in Iowa

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August 2004

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1 Introduction

The objective of this project is to compare energy consumption and incremental building costs for single-family residential homes built and operated according to either the 2000 International Energy Conservation Code (2000 IECC) or some lesser code such as the 1992 Model Energy Code (1992 MEC). Guidance for building homes with the goal of reducing energy consumption is provided by the 2000 IECC [1] and by the 1992 MEC [2]. Presently, builders in Iowa are not mandated by law to follow these codes. A major obstacle to adopting a code or even making recommendations to voluntarily follow a code in Iowa is the lack of quantitative information comparing the codes. Specifically, information and data are lacking for both energy savings and incremental building costs. This report attempts to answer the question of how much energy savings can be achieved in Iowa by implementing energy savings steps described in 2000 IECC.

At the outset of the project, 30 homes within the state of Iowa were identified to be included in the study. Ten homes were chosen from each of the three climate zones of Iowa to determine if homes were built to 2000 IECC standards or lesser standards. The initial pool of homeowners was obtained by writing to county engineers and zoning engineers in each of Iowa's 99 counties, requesting names of residents whose homes might fit the criteria. The ISU research team sent a letter and survey to the homeowners inviting them to participate in the study. The survey was used as a screening tool to ensure that a home was constructed within the last 20 years. The study limited the heating and cooling systems to a natural gas furnace and an electric air-conditioner, respectively.

After homeowners agreed to participate, the ISU research team made arrangements to visit each homeowner to perform an energy audit of the home. Each home was visually inspected and relevant building data was estimated and/or measured. For example, the audit was used to obtain building size, window numbers and sizes, building layout and construction, orientation, landscaping, etc. Each homeowner agreed to release utility information so that energy consumption data could be obtained for a two-year period. The natural gas and electrical energy consumption data was then used to complete the following tasks:

1. Compile and tabulate raw energy data for the energy consumption analysis. Examples of this data are monthly energy consumption, occupancy, thermostat temperature settings, building dimensions and size, etc.

2. Correlate the energy consumption data from Task 1 with weather, building size and temperature.

3. Determine the energy savings associated with houses built to the 2000 IECC standards versus 1992 MEC standards or lesser. Compare, interpret and summarize energy consumption and savings.

4. Determine the construction and material costs associated with compliance to 2000 IECC and the incremental costs of using energy efficient materials versus standard materials.

2 1992 MEC Versus 2000 IECC

The 1992 MEC [2] and the 2000 IECC [1] are a set of standards that can be followed by a home builder when building an energy efficient home. Table 2.1 summarizes the differences between the two codes, with the major differences being related to allowable air infiltration rates, duct insulation and sealing. Both the 1992 MEC and 2000 IECC are divided into four major sections, which are described in the subsections that follow:

1 Building envelope requirements
2 Building mechanical systems and equipment
3 Service water heating
4 Electrical power and lighting

2.1 Building Envelope Requirements

The term building envelope refers to the walls, roof, floors, and fenestrations that enclose the building. A fenestration is any glazed aperture in a building envelope such as a window [1].

The main purpose of the building envelope requirements section is to specify the thermal resistance, usually called the heat transfer coefficient *U*, required for components of the house such as the walls, roof/ceiling, basement walls, crawlspace walls, and floors over unheated spaces. Thermal resistance is the ability for a material to transfer heat and the units are Btu/h·ft^2·°F. The thermal heat transfer coefficient for each of the components previously listed can be found on appropriate charts in the energy code and is based upon the annual Fahrenheit heating degree days for the house of interest.

A single heating degree day can be calculated using the following equation [3]:

$$HDD = \frac{(t - t_a)N}{24}$$

where t = 65 °F represents a baseline outdoor temperature, t_a is the average outside temperature (in °F), N is the number of hours for which the average temperature t_a is computed, and HDD is the heating degree day for a period (in °F-day) [4].

For example, if the average outside temperature, t_a, over a 24 hour period on January 15 in Des Moines, IA is 25 °F, the heating degree days (HDD) for this particular day is 40 °F-day. Further, if the average outside temperature, t_a, over a 24 hour period on July 15 in Des Moines, IA is 75°F, then the HDD for this particular day is 0 °F-day since HDD cannot have a negative value. It is worthwhile to note that if the HDD calculation results in a negative number, then that day is referred to as a cooling degree day (CDD). To find the annual Fahrenheit heating degree days for Des Moines, IA, all of the heating degree days for the entire year are added together. Thus, during the year 2003, the total HDD was approximately 6262 °F-day. For the state of Iowa, the typical heating months are October through May and the cooling months are June through September.

Table 2.1. Summary and comparison of the 1992 MEC and 2000 IECC.

SUBJECT	1992 MEC	2000 IECC	COMMENTS
Allowable Air Infiltration Rates for Windows	0.34 cfm per foot of operable sash crack	0.3 cfm per square foot of window area	The maximum air leakage rates for windows have been reduced in the 2000 IECC.
Allowable Air Infiltration Rates for Sliding Doors	0.5 cfm per square foot of door area	0.3 cfm per square foot of door area	The maximum air leakage rates for sliding doors have been reduced in the 2000 IECC.
Duct Insulation	No Requirements	R-5	According to the 2000 IECC, ducts in unconditioned spaces such as attics, basements, and crawlspaces need to be insulated to R-5, whereas in the 1992 MEC, ducts in these same unconditioned spaces do not need to be insulated. If the temperature difference between the space within which the duct is located and the design temperature in the duct is greater than 40 degrees Fahrenheit then R-5 is required. If the temperature difference between the space within which the duct is located and the design temperature in the duct is less than or equal to 40 degrees Fahrenheit, but greater than 15 degrees Fahrenheit then R-3.3 is required. If the temperature difference between the space within which the duct is located and the design temperature in the duct is less than or equal to 15 degrees Fahrenheit then no insulation is required.
Duct Sealing	No Requirements	Newly approved tapes and mastics	According to the 2000 IECC, duct sealing provisions apply to all supply and return ducts. Only approved tapes and mastics are allowed for duct sealing and duct tape is not allowed as a sealant.
Recessed Lighting Fixtures	No Requirements	Requirements Provided	Provisions have been added for recessed lighting fixtures for fire safety and to limit heat loss and air infiltration.
Steel Stud Framed Walls	No Requirements	Requirements Provided	Criteria have been added to correct for increased heat loss from metal stud framing in exterior wall thermal calculations.
Ventilated Crawlspace Walls	No Requirements	Insulation now required	Insulating the wall of ventilated crawlspaces is not an option. If the crawlspace is ventilated, insulation on the ceiling of the crawlspace is required.
Prescriptive Building Envelope Requirements	No Requirements	Requirements Provided	The prescriptive building envelope requirements are a set of tables that provide the maximum glazing U-factor for windows and the minimum R-value for components such as the ceiling, exterior walls, floor, basement walls, etc. based upon the fraction of window area to gross exterior wall area and the annual heating degree days for a particular home. The prescriptive building envelope requirements eliminate the difficulty of looking up minimum R-values for the ceiling, exterior walls, floor, basement walls, etc. and maximum U-factor for windows from multiple charts.

Conveniently, the 2000 IECC has a chart that can be used to find the maximum heat transfer coefficient *U* for walls. The maximum heat transfer coefficient *U* is specified along the vertical axis and the annual Fahrenheit heating degree days is specified on the horizontal axis. Further, this chart has two lines on it labeled A-1 and A-2, with line A-1 representing single-family residential homes and A-2 representing multiple-family residential homes; therefore, A-2 can be neglected in the study reported herein. Additional charts in the 2000 IECC only have one line representing both A-1 and A-2 type homes. These charts are used to find the maximum heat transfer coefficient *U* for the roof/ceiling, basement walls, crawlspace walls, and floors over unheated spaces.

One advantage that the 2000 IECC has over the 1992 MEC is that it contains prescriptive building envelope requirements. This advantage is shown in Table 2.1 where the major differences between the 1992 MEC and 2000 IECC are compared. The prescriptive building envelope requirements are a set of tables that provide the minimum insulation *R*-values for the walls, roof/ceiling, basement walls, crawlspace walls, floors over unheated spaces, and the maximum glazing *U*-factor for the windows, all of which are based upon the annual Fahrenheit heating degree days and the ratio of window area to gross exterior wall area. The advantage of the prescriptive method is that a home builder can look up the insulation *R*-values and glazing *U*-factors from one table instead of referring to several graphs. Also, most home builders are probably more familiar with insulation *R*-values and glazing *U*-factors than they are with heat transfer coefficients.

2.2 Building Mechanical Systems and Equipment

2.2.1 Overview

This section of the two codes covers the mechanical systems and equipment used to provide heating, ventilating, and air conditioning. It provides the minimum performance rating for equipment such as heat pumps, furnaces, boilers, and air conditioners. It also provides requirements for the construction and insulation of the distribution system [1].

The typical home in Iowa has a gas-fired furnace or a heat pump for heating during the winter, and an air-cooled air conditioner or a heat pump for cooling during the summer. The minimum performance for these components according to the 1992 MEC and 2000 IECC are listed in Table 2.2.

Table 2.2. Minimum performance requirements for heating and cooling equipment according to 2000 IECC.

EQUIPMENT CATEGORY	MINIMUM PERFORMANCE
Air-cooled heat pumps with heating mode less than 65,000 Btu/h cooling capacity	6.8 HSPF
Gas-fired or oil-fired furnace less than 225,000 Btu/h	AFUE 78%
Air-cooled air conditioners and heat pumps with cooling mode less than 65,000 Btu cooling capacity	9.7 SEER

2.2.2 Heating Seasonal Performance Factor Requirements

The Heating Seasonal Performance Factor (HSPF) is an efficiency rating for heat pumps. It is a measure of the average number of Btu of heat delivered for every Watt-hour of electricity used by the heat pump over the heating season [5]. It takes into account variations due to weather conditions over a season. The higher the HSPF, the more efficient the heat pump heating performance. Industry minimums for HSPF have been raised recently, and the minimum is now 6.8 HSPF. Most new units have ratings from 7.0 to 9.4 HSPF. According to both the 1992 MEC and 2000 IECC, the minimum performance rating for air-cooled heat pumps while in the heating mode is 6.8 HSPF [1,2].

2.2.3 Annualized Fuel Utilization Efficiency Requirements

The Annualized Fuel Utilization Efficiency (AFUE) is the ratio of the total useful heat your gas furnace delivers to your house to the heat value of the fuel it consumes [5]. A higher AFUE rating indicates a more efficient furnace. For example, a rating of 90 AFUE means that approximately 90% of the fuel is utilized to provide heat to your home, while the remaining 10% escapes as exhaust. The U.S. government's established minimum AFUE rating for furnaces is 78% for products produced after July 1992 [6]. An older furnace could be as low as 50% AFUE. According to both the 1992 MEC and 2000 IECC, the minimum performance rating for oil-fired or gas-fired furnaces is 78% AFUE [1,2].

2.2.4 Seasonal Energy Efficiency Ratio Requirements

The Seasonal Energy Efficiency Ratio (SEER) is a rating that denotes the efficiency of air conditioning equipment. It is the amount of cooling your equipment delivers for every dollar spent on electricity. It is the ratio of cooling delivered by a system, measured in Btu, to the dollar cost of the electricity to run the system, as measured in Watt-hour [5]. This ratio is determined using specified federal test procedures. It should be noted that higher SEER ratings result in higher efficiencies and lower operating costs. After January 1, 1992, the minimum SEER required by the Department of Energy, DOE, is 10 and 15+ SEER is considered high efficiency [6]. According to both the 1992 MEC and 2000 IECC, the minimum performance rating for air-cooled air conditioners and air-cooled heat pumps while in the cooling mode is 9.7 SEER [1,2].

2.2.5 Duct Sealing and Insulating Requirements

The 2000 IECC has stricter requirements for duct insulating and sealing than the 1992 MEC. The 2000 IECC specifies that all supply ducts within unconditioned spaces, such as an unheated basement or attic, must be insulated, whereas the 1992 MEC does not specify this requirement. Also, the 1992 MEC allows for duct tape to be used to seal duct seams, but the 2000 IECC does not allow duct tape to be used as a sealant. The reason that the 2000 IECC finds duct tape unacceptable is that duct tape has a tendency to deteriorate over time. These differences between the 1992 MEC and the 2000 IECC for duct sealing and insulating are presented in Table 2.1.

2.3 Service Water Heating

2.3.1 Overview

The purpose of this section is to provide energy efficient requirements for designing and installing service water heating equipment. It provides the minimum performance rating for equipment, such as water heaters, storage tanks, and boilers, as well as the minimum insulation levels for the piping.

2.3.2 Pipe Insulation Requirements

The minimum pipe insulation requirements according to the 2000 IECC are shown in Table 2.3.

Table 2.3. Minimum pipe insulation specifications [1].

SERVICE WATER-HEATING TEMPERATURES (°F)	PIPE SIZES			
	Noncirculating runouts	Circulating mains and runouts		
	Up to 1 inches	Up to 1.25 inches	1.5 to 2 inches	Over 2 inches
170-180	0.5 inches	1.0 inches	1.5 inches	2.0 inches
140-169	0.5 inches	0.5 inches	1.0 inches	1.5 inches
100-139	0.5 inches	0.5 inches	0.5 inches	1.0 inches

2.3.3 Electric Water Heaters

Automatic electric-storage water heaters having a storage capacity of 120 gallons or less and an output rating of 12 kW or less must have a standby loss not to exceed 4.0 W/ft^{2}of tank surface area or 43 W, whichever is greater [2].

Automatic electric-storage water heaters having either a storage capacity greater than 120 gallons or an input rate greater than 12 kW must have water-backed storage tank surfaces insulated to at least *R*-10 or have a standby loss not to exceed 4.0 W/ft^2 [2].

2.3.4 Gas-fired and Oil-fired Water Heaters

Gas-fired and oil-fired automatic storage water heaters having an input rating of 75,000 Btu/h or less must have a recovery efficiency (E_r) not less than 75% and a standby loss (S) not to exceed:

$$S = 2.3 + 67/V$$

where S is the percent per hour of stored thermal energy and V is the rated volume in gallons [2].

2.4 Electrical Power and Lighting

This section provides the requirements for energy efficient electrical power and lighting systems. Some of these requirements are illumination level criteria, and reflectance and light loss factors.

2.5 Summary

Of the requirements summarized in Sections 2.1-2.4, the sections dealing with service water heating and electrical power and lighting were not considered for the study reported herein. These two sections were not emphasized because requirements in the 1992 MEC and the 2000 IECC are similar.

The 1992 MEC and the 2000 IECC were compared to each other to understand both their similarities and differences. It was found that the 1992 MEC and the 2000 IECC were similar to each other in many ways when comparing the design and construction requirements for single-family residential homes. For example, the building envelope requirements and minimum equipment performance requirements for components such as heat pumps, furnaces, boilers, and air conditioners were the same in both the 1992 MEC and 2000 IECC. Even though there are many similarities between the 1992 MEC and the 2000 IECC, there are a few major differences such as allowable air infiltration rates, duct sealing and insulation requirements. Furthermore, the 2000 IECC describes a prescriptive method to determine if a home meets code standards.

3 Demographics of Homes Selected

3.1 Overview

Thirty homes representing a variety of home styles and weather regions in Iowa were selected for this study. The division of the weather regions for the state of Iowa was established by [1]. A summary of the homes in each style and weather category is tabulated in Table 3.1. As shown in the table, the thirty homes were divided equally among the three Iowa weather regions: northern, central and southern. Ten homes were selected in each of the three regions. Furthermore, within each region, the homes were then divided about equally between single-story or ranch style (16 homes) and multi-story (14 homes), including a combination of two-story homes (8) and split-level and 1-1/2 story homes (6 homes). Schematics of the home styles for ranch, 2-story and split-levels can be found in Figs A.1-A.6. A summary of the basic home features according to each region can be found in Tables A.1-A.4.

Table 3.1. Summary of the style home within each weather region of Iowa.

	Ranch style	2-story style	Split-level style/ 1-1/2 story	**Total**
Region A (Northern)	6	1	3	**10**
Region B (Central)	4	3	3	**10**
Region C (Southern)	6	4	0	**10**
Total	**16**	**8**	**6**	**30**

The ages of the homes varied from 2 years old (the minimum age required to participate in the study) to 20 years old. The number of homes in each age category is listed in Table 3.2. The home age is relative to the year 2002, which is when this study began. Thus, only homes that were built prior to December 31, 2001 would qualify. This criterion also limits the age of any home constructed according to the 2000 IECC to two years old. At least 8 two-year old homes were selected for analysis in this study. Even though homes older than two years would not have followed the 2000 IECC during construction, it should be recognized that other homes (especially newer homes) may in fact comply with the various criteria (i.e., wall and ceiling insulation, glazing, etc.) of the 2000 IECC energy requirements. The same argument also pertains to the 1992 MEC.

The size of the homes selected, corresponding to the floor area, varied from 1025 ft^2 to 3065 ft^2. It should be noted that throughout this report the floor area does not include the basement, regardless of whether the basement was heated or not. The window area of the homes varied from 110 ft^2 to 357 ft^2. The percentage of the wall area (based on estimated values) to percentage of window area varied from 8% to 24%. The window and wall dimensions (multiply by 100% for the wall area percentage) are tabulated in Table A.5

As noted elsewhere in this report, all of the homes were heated by natural gas furnaces and cooled by standard (vapor compression) air-conditioning systems.

Table 3.2. Number of homes and corresponding years since construction, relative to 2002.

Age of home (years) relative to 2002	Number of homes
2	8
3	3
4	1
5	1
6	1
7	5
8	1
9	3
10	1
11	1
12	3
13	1
14	0
15	0
16	0
17	0
18	0
19	0
20	1

3.2 Identification of 2000 IECC Homes

Based on numerous interactions with both homeowners and builders, it can be concluded that there is a general lack of public knowledge concerning the energy efficiency requirements specified in the 2000 IECC. In addition, the lack of knowledge and the fact that the 2000 IECC standards are not mandated, except in a few rare cases, it can also be concluded that most newly constructed homes are not specifically constructed with the intention of satisfying the 2000 IECC. However, it should be noted that there has been interest throughout society (especially with the home-building community) during the past two decades to conserve energy and thus follow energy efficient practices, such as installing extra insulation in walls/ceilings and minimizing infiltration in windows/doors. Tables A.1-A.4 highlight the basic features known for each home derived from the homeowner survey and energy audit.

As a result, even though homes may not have followed an energy code during new construction, homes may in fact satisfy either part or all of the requirements of the 2000 IECC. Evidence that homes built within the last two years may satisfy the code was documented in a study by the Britt/Makela Group (Britt/Makela Group, Inc. 2004). According to Britt/Makela, their study

investigated 65 single-family residential homes in Iowa that were newly constructed to determine whether these homes satisfied the 2000 IECC requirements. Based on plan reviews and field inspections, the Britt/Makela Group concluded that nearly all of the newly constructed homes satisfied 2000 IECC requirements. Based on this conclusion and the energy audit inspections conducted for this study, it can probably be assumed that the 2 year-old homes selected in the study herein can be classified as 2000 IECC homes. Of the 30 homes listed in Table 3.2, 8 homes were built in 2000. Even so, as will be shown later in this report, a quantitative method using *UA* values will be used to select the homes that meet 2000 IECC standards.

In addition to the 8 newly constructed homes in this study, 3 other homes were identified during the energy audit as probably satisfying 2000 IECC building requirements. One home is 4 years old and the audit showed that the duct seams were all insulated which is one of the hallmarks of the 2000 IECC requirements (refer to Table 2.1). Another home is 13 years and the ducts were taped and well insulated. Finally, a 6 year-old home in the study received an energy star rating from MidAmerican Energy, which may in fact be comparable to the 2000 IECC requirements.

Other homes in this study appear to satisfy the energy efficiency requirements of the 2000 IECC. These homes were identified by comparing experimental thermal conductance *UA* values, as determined from energy consumption data provided by utilities to *UA* values calculated from the guidelines provided in the 2000 IECC. Specifically, the thermal conductance represents a measure of the energy efficiency of a building envelope (refer to Section 2.1 and Section 4.4). Therefore, if the actual experimental *UA* is less than the *UA* calculated by using guidelines in the 2000 IECC, then the home satisfied the energy efficiency demanded by the code. As will be shown in Section 4.5, a total of 16 homes out of the 30 are considered to satisfy 2000 IECC standards for the purposes of the study reported herein.

4 Analysis of Energy Consumption

4.1 Heating Degree Days

The heating degree days (HDD) were determined for each of the three Iowa weather regions, namely the northern, central and southern regions. The HDD calculation is important for two reasons. First, the values of HDD are used later in the study to calculate an experimental overall thermal conductance *UA* for each home. Second, a comparison of the annual HDD for each of the three regions provides an indication of how the outdoor temperature might vary for each geographical location. It is expected that the energy consumption for heating should increase as the outdoor temperature decreases, which in turn increases the HDD.

The HDD were defined in Section 2.1 assuming a base (outdoor) temperature of 65 °F. The HDD region weather data was obtained through the National Climate Data Center [4] for locations central to each of the three Iowa regions. Using this data, the HDD per day were calculated and plotted for each of the three regions over the two-year period, as shown in Fig. 4.1. As one would expect, the HDD per day is highest during the coldest months and then set to zero when the outdoor temperature is greater than the base temperature of 65 °F, meaning that heating is not required.

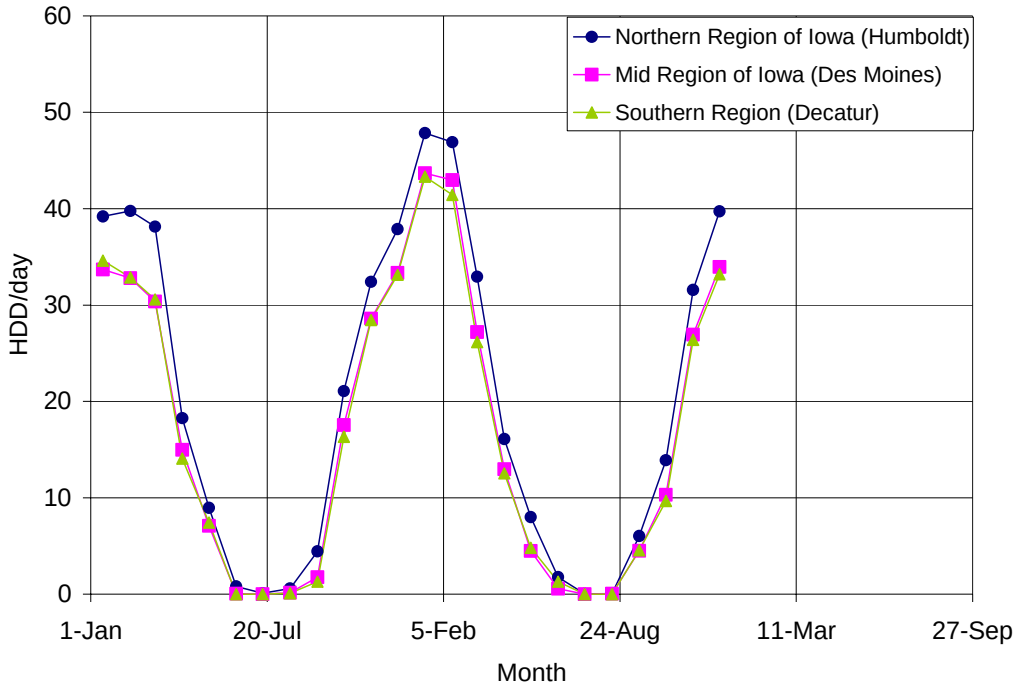

Fig. 4.1. Heating degree days over two years (January 2002 through December 2003) for locations in each weather region of Iowa.

The total HDD for one-year and two-year periods were determined for all three Iowa weather regions by integrating (i.e., totaling) each curve shown in Fig. 4.1. The result is that on a one-year basis the northern, central and southern regions have HDD of 7480, 6363 and 6225, respectively, and on a two-year basis, the HDD for the three regions are 14606, 12250 and 12076, respectively. An observation is that the HDD for the lower two regions are similar, being within 2% of each other. The difference between the northern and central region is16% and the difference between the northern and southern region is 18%. These differences are primarily during the peak heating month of January. As will be shown in the data analysis, the HDD can be used to normalize data.

4.2 Energy Consumption

The energy from natural gas and electricity for each home over a two-year period was obtained from utility companies. The energy consumption was provided as total amounts for a billing cycle; generally a billing cycle was 30 days. The natural gas consumption was in units of therms and the electricity was in units of kiloWatt-hours (kW·h).

The gas and electricity consumption were both converted to Btu. The conversion for electricity is simple, being 3.413 Btu/kW·h, however, converting therms to Btu is more difficult. The therm unit for natural gas represents 100 cubic feet of natural gas. Even though natural gas is mostly methane, natural gas contains other components so that the actual energy content (Btu) of a therm can vary. However, on average each cubic foot of natural gas releases about 1000 Btu of thermal energy. Therefore, for the purposes of this study, therms can be converted to Btu of thermal energy by using a conversion factor of 10^5 Btu per therm.

The raw energy consumption data provided by utilities, converted to units of Btu, are tabulated in Tables B.1 through B.30 (Appendix B) for each of the 30 homes analyzed in this study. For each billing cycle, the total energy consumed (Btu) within a given cycle can be converted to represent an *average daily use* (Btu/day) by dividing by the number of days in a billing cycle. The average daily use can be represented as a mean value at a day in the middle of the billing period. Thus, the number of days in a two-year period ranges from 1 to 730 days. The middle of each billing cycle is shown for each home under the heading “day”. The average daily energy consumption for each billing cycle was further divided by house size, i.e., floor area, so that the energy consumption for all 30 homes could be compared on a common basis of per unit area of floor space. The modified data for consumption of natural gas and electrical energy can now be analyzed and compared for the two-year study period by plotting Btu/ft^2·day versus the day of the year. Figures C.1 through C.30 (Appendix C) are plots for each home; both natural gas and electrical energy are shown in each plot.

Several observations that are common to all 30 homes can be made regarding the data plotted in Figs. C.1–C.30. First, the natural gas consumption increases in the colder months (e.g., winter) because the gas furnace operates to heat a house. Furthermore, natural gas is consumed even in the summer to operate appliances such as a stoves and/or hot water heaters. Even though the baseline gas consumption during non-heating months varies from home to home, an average value is about 50 Btu/ft^2·day. Second, the electrical energy consumption increases in the warmer months (e.g., summer) because the air-conditioning unit operates to cool the house. Electricity

consumption is also prevalent during the non-cooling months to operate appliances and lights, and in some cases hot water heating. It is not uncommon for households to supplement gas heating with some type of electrical space heating. Even though the baseline electricity consumption during non-cooling months varies from home to home, an average value is about 50 Btu/ft^2·day.

The data in Figs. C.1–C.30 show that the peak gas consumption in the month of January varies from home to home, with a low value of 150 Btu/ft^2·day to a high value of 400 Btu/ft^2·day. In addition, the peak electrical consumption in the summer varies from 25 to 250 Btu/ft^2·day. Another observation from these figures is that the gas and electrical energy consumption relative to each other varies considerably from home to home. However, generally, the gas consumption is several times higher than the electricity consumption signifying that in a northern climate state such as Iowa, heating loads are larger than cooling loads.

4.3 Cost Comparison

The natural gas costs for heating a home were determined by summing the natural gas consumption for the heating season for both a one-year and two-year period. Likewise, the total electricity costs for cooling a home were summed for the cooling season for both a one-year and two-year period. The total one-year and two-year gas and electricity consumption are shown in Tables A.3 and A.4, respectively, in Appendix A. The one-year gas consumption for heating varies from 5.05×10^7 Btu to 16.96×10^7 Btu, whereas for two years, consumption varies from 10.3×10^7 Btu to 33.8×10^7 Btu. The one-year electrical energy consumption for cooling varies from 1,830 kW·h to 7,852 kW·h, while for two years, consumption varies from 3,109 kW·h to 15,389 kW·h.

The natural gas costs for heating were based on an assumption of $1.00 per therm. Actual natural gas costs vary from year to year and also with season and location. Thus, the assumed value of $1.00 per therm represents a typical value that a homeowner might be charged. The electricity costs also vary, however a typical value of 10¢ per kW·h was selected for the cost analysis presented herein. These rates for gas and electric consumption were used to calculate the total one-year and two-year costs for heating and cooling each home, shown in Tables A.3 and A.4, respectively.

The total costs for natural gas are plotted in Figs. 4.2 and 4.3 for one-year and two-year heating seasons, respectively, as a function of the year in which each home was built and style of home. The “other” category represents split-level and 1-1/2 story home styles. The lack of trends is not surprising in that total heating costs vary considerably with home size, home construction (e.g., insulation, infiltration, etc.), number of people, thermostat settings, energy conservation practices of owners, etc. The one-year costs vary from $500 to $1700 while the two-year gas heating costs vary from $1000 to $3400.

The electrical costs for cooling were also determined versus the year each home was built for both a one-year and two-year period, as shown in Figs. 4.4 and 4.5, respectively,. The one-year electricity costs vary from $180 to $800 while the two-year electricity costs vary from $400 to

about $1500. There is no evident trend for electricity consumption as a function of home age based on the same reasons that were discussed previously when heating costs were presented.

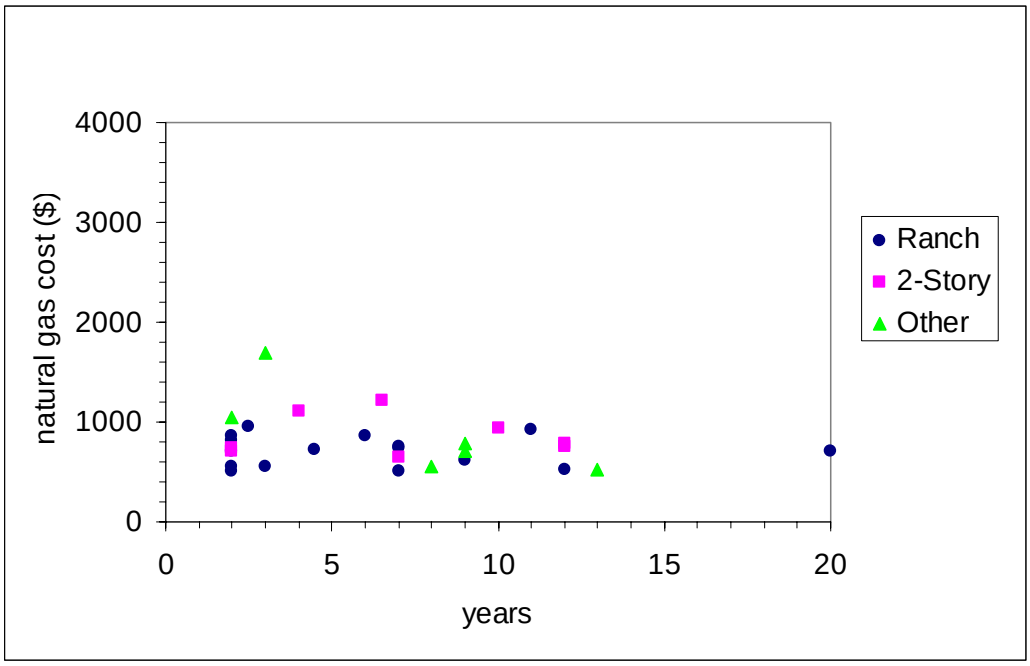

Figure 4.2. Cost of natural gas versus age of home for a one-year heating season.

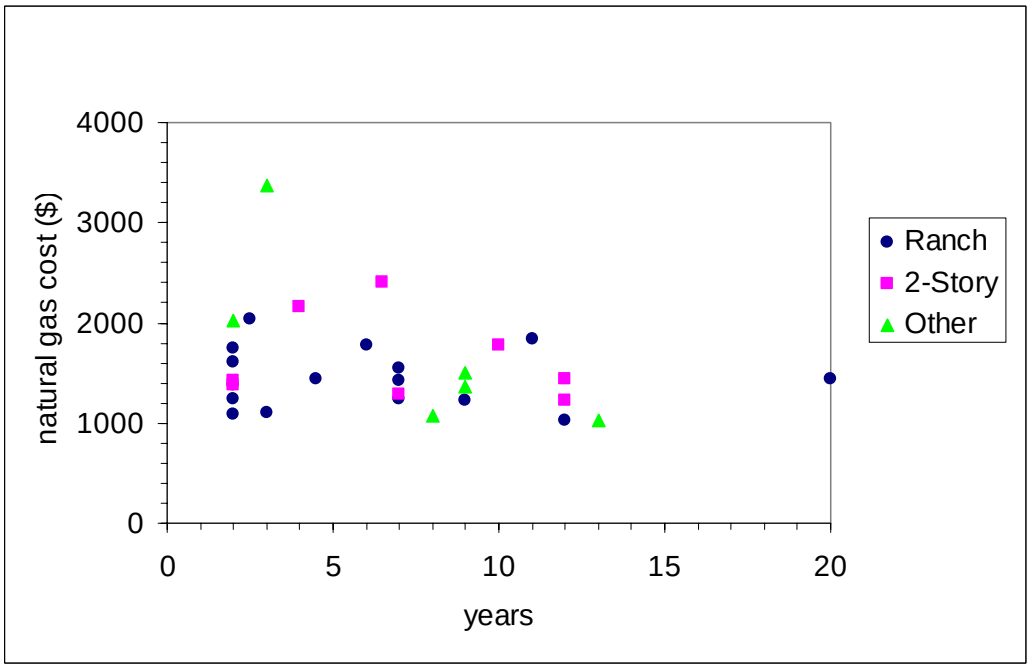

Figure 4.3. Cost of natural gas versus age of home for a two-year heating season.

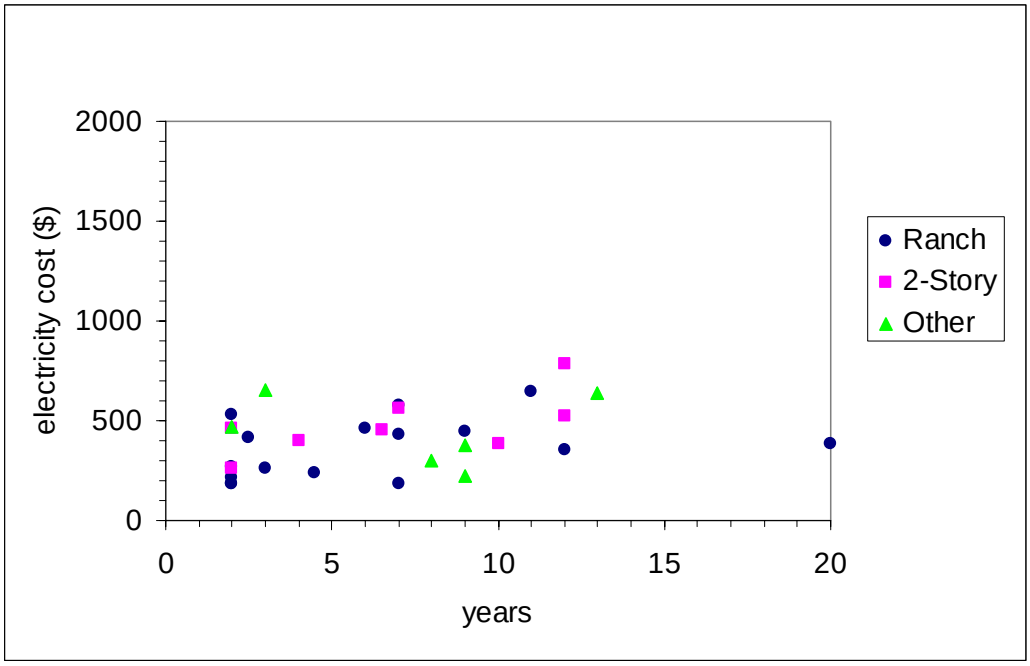

Figure 4.4. Cost of electricity versus age of home for a one-year cooling season.

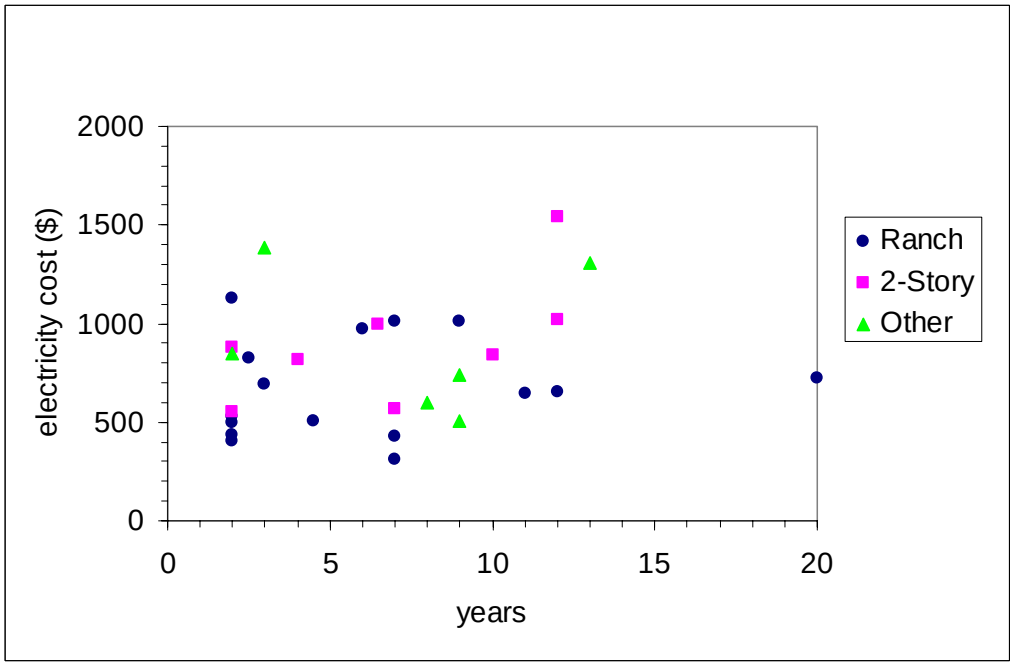

Figure 4.5. Cost of electricity versus age of home for a two-year cooling season.

4.4 Experimental Building Envelope *UA* values

The overall thermal conductance *UA* for each home was determined by plotting the average gas consumption per hour for a billing cycle (Btu/h) versus HDD per day, for a one-year period, as shown in Figs. D.1–D.30. The one-year period represents the 2002–2003 winter, which provides one complete heating season. Referring to Fig. 4.1, the complete heating season (that provides consecutive information) runs from October 2002 through May 2003. After plotting the data for each home, a linear regression of the data was calculated, where the slope represents the *UA*, with units of Btu/h·°F. The physical significance of the *UA* is that it represents the energy efficiency of the building envelope since energy transfer rates from a home can be found by multiplying *UA* by the indoor-to-outdoor temperature difference. For example, a large *UA* means large heat losses and therefore, to promote energy efficiency, small *UA*s are desirable.

The experimental *UA* values are plotted for each home as a function of the age of the home in Fig. 4.6. Again, there is no direct correlation between age of a home and a dependent variable such as *UA*. The *UA* values plotted vary from 297 to 1190 Btu/h·°F. Figure 4.7 shows the relationship between *UA* versus floor area with a clear trend that as the floor area increases, *UA* increases. In the case of *UA* versus wall area shown in Fig. 4.8, the data indicates that ranch-style homes have lower *UA* values than 2-story style homes, however, there is no definite trend for the split-level and 1-1/2 story homes ("other" category). The trend between *UA* and window area shown in Fig. 4.9 is the same as that for floor area in that *UA* also increases with window area. Summarizing, Figs. 4.7-4.9 indicate that trends exist based on floor and window area, where *UA* increases with increasing area. For wall area, the trend indicates that *UA* can be categorized by style of home.

Based on the aforementioned trends, a multiple regression analysis was used to predict *UA* values according to home dimensions (floor, wall and window areas) and style of home. The Buckingham pi theorem was used in the regression analysis [8]. The pi-terms were nondimensionalized by the wall area based on the discussion of Fig. 4.8. The predicted *UA* values can be found by the following:

$$UA = F(\pi_1)^a (\pi_1)^b \tag{4.1}$$

where π_1 is the ratio of floor area to wall area, π_2 is the ratio of window area to wall area, and *F* is a constant with units of Btu/ h·°F. Table 4.1 contains the coefficients that satisfy Eq. 4.1. Figure 4.10 shows the relationship between the experimental *UA* and the predicted *UA*. A linear line is also shown in the figure with a slope of unity to demonstrate the deviation or error of the experimental data. The dashed lines further demonstrate that the experimental *UA* values lay within ± 20% error.

Table 4.1. Multiple regression coefficients to predict *UA* based on Eq. 4.1.

Style	*F*	*a*	b
Ranch	6.6718	0.2485	0.2987
2-Story	6.1916	1.759	-0.1059
Other	3.6178	1.5186	-1.2974

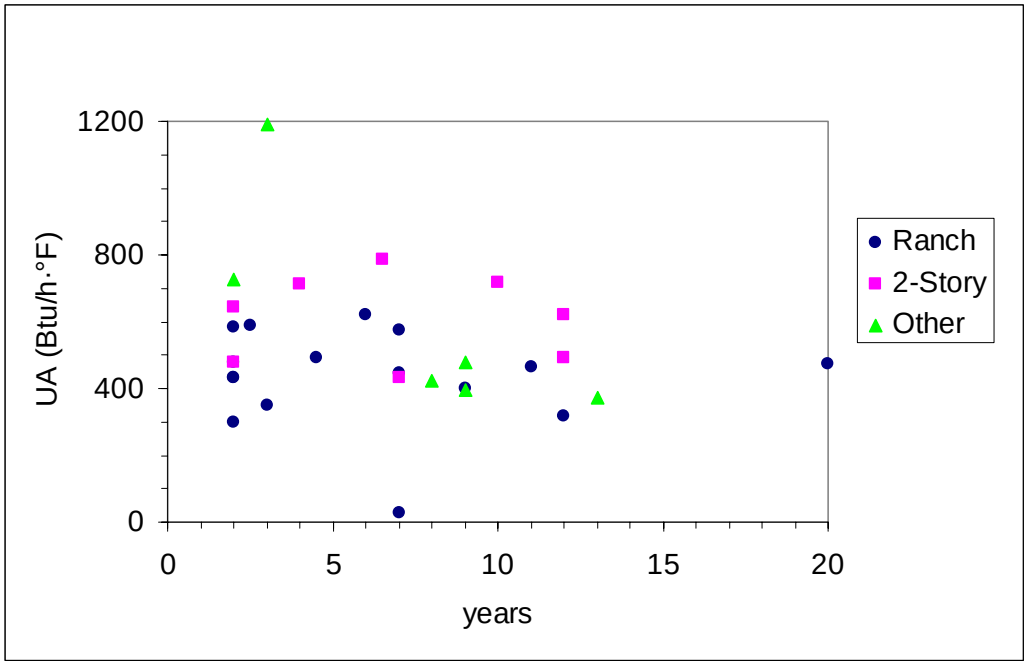

Figure 4.6. Experimental *UA* versus age of home.

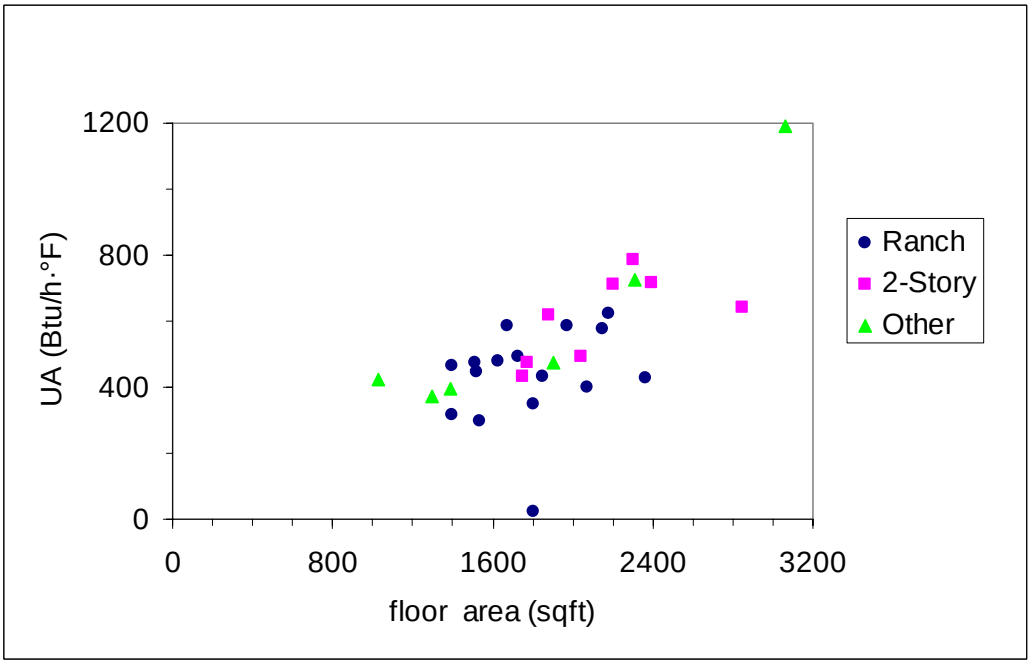

Figure 4.7. Experimental *UA* versus floor area.

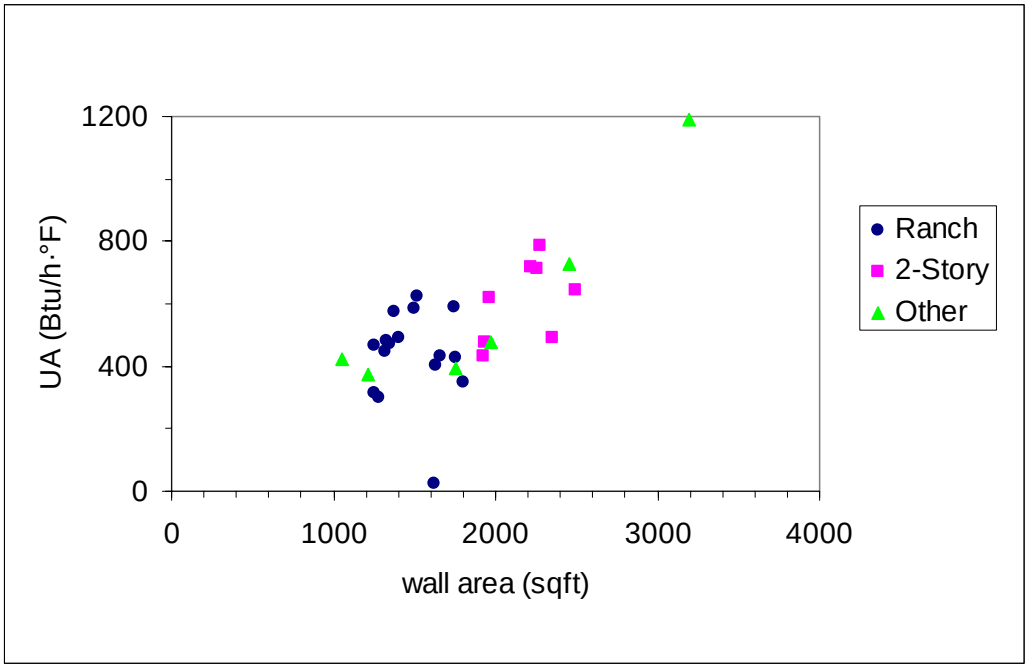

Figure 4.8. Experimental *UA* versus wall area.

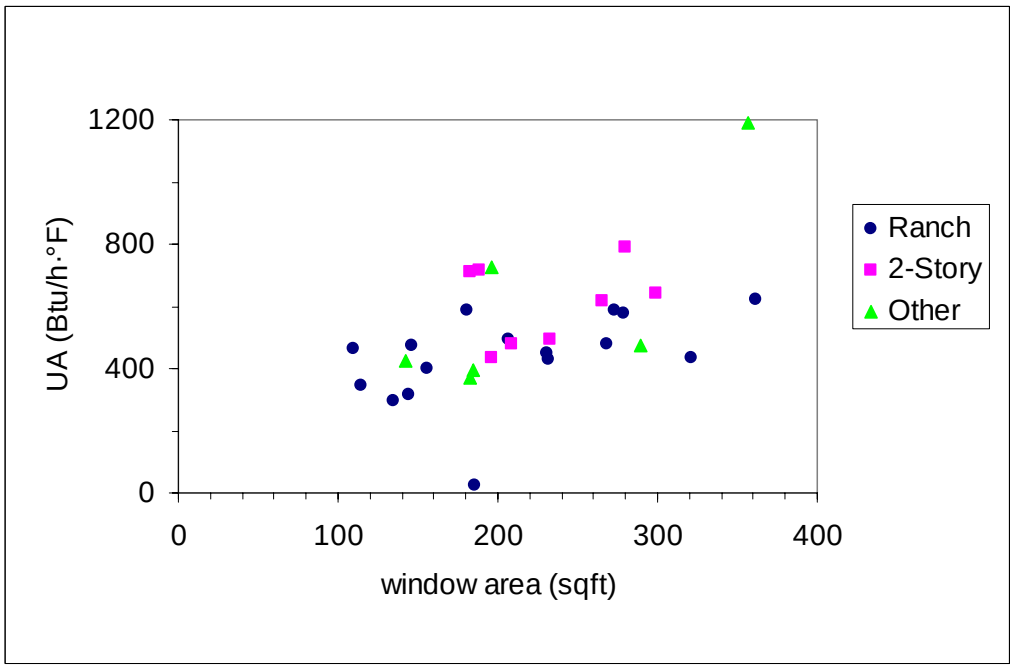

Figure 4.9. Experimental *UA* versus window area.

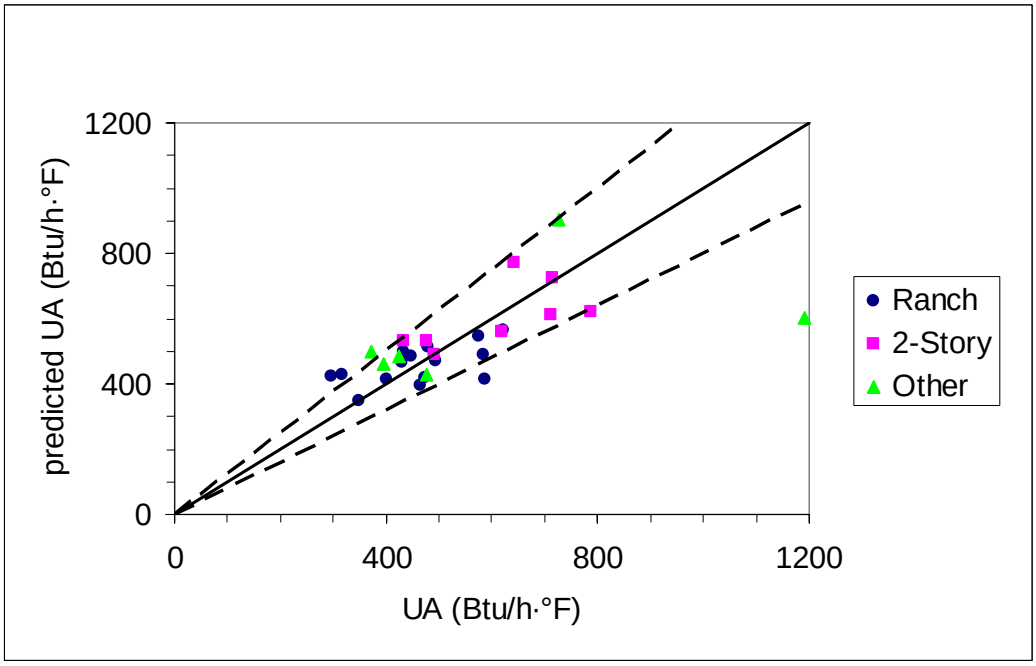

Figure 4.10. Predicted *UA* versus experimental *UA* correlated for each style of home. The dashed lines represent ±20% error intervals.

4.5 Comparison of Experimental and 2000 IECC *UA* Values

In an effort to determine which of the 30 homes selected for this study actually meet the 2000 IECC, *UA* values were calculated by using the energy efficiency guidelines provided by the 2000 IECC. The experimental *UA* values for each of the 30 homes (refer to Section 4.4) were compared to the *UA* values calculated according to 2000 IECC. Because there has been some emphasis on building energy efficient homes in the last two decades, even without mandated guidelines from codes, there may in fact be a number of older homes that were built to either the 1992 MEC or 2000 IECC standards.

The 2000 IECC provides guidelines for constructing single-family homes by providing for minimum wall and ceiling insulation requirements in the form of *R*-values, along with window glazing and basement wall requirements in the form of *U*-values. Therefore, *R*- and *U*-values, which are functions of HDD, can be taken from tables and graphs contained within the 2000 IECC and can be used to guide energy efficient construction of homes [1].

Even though the homes in this study are built, each of the 30 homes can be modeled by using *R*- and *U*-values from the 2000 IECC to determine what value the *UA* would be if in fact the homes had been constructed according to the code. The *UA* model is as follows:

$$UA = U_{\text{window}} A_{\text{window}} + \frac{A_{\text{ceiling}}}{R_{\text{ceiling}}} + \frac{A_{\text{wall}}}{R_{\text{wall}}} + U_{\text{basement}} A_{\text{basement}} \qquad (4.2)$$

The four surface areas shown in Eq. 4.2 are unique to each of the thirty homes, and they were determined during the on-site energy audit visit. These areas are tabulated for each home in Table A.5. The *R*- and *U*-values were taken from the 2000 IECC, and in some cases they are functions of the HDD and thus home location (northern, central and southern). Values for *R* and *U* used in Eq. 4.2 are:

U_{window} = 0.35 Btu/h·ft^2·°F
$R_{ceiling}$ = 38 hr·ft^2·°F/Btu
R_{wall} = 9.1 hr·ft^2·°F/Btu (northern region)
R_{wall} = 8.0 hr·ft^2·°F/Btu (central and southern regions)
$U_{basement}$ = 0.093 Btu/h·ft^2·°F (northern region)
$U_{basement}$ = 0.095 Btu/h·ft^2·°F (central and southern regions)

The *UA* values for each of the 30 homes are shown in Table 4.2, denoted as "2000 IECC *UA*".

A second approach for determining *R* and *U* values, called the "prescriptive method", is also provided in the 2000 IECC. As before, the *R* and *U* values can be used to calculate *UA* in Eq. 4.2. Using the prescriptive method, *R* and *U* values as functions of percent window area and HDD can be found in a series of tables presented in the 2000 IECC. The percent window area is based on the gross exterior wall area, which is 100% times the ratio of the window area to wall area. Unlike the first method previously discussed, the *R* and *U* values in the prescriptive method will vary from home to home, depending on the glazing to wall ratio and the HDD associated with the location of the home. Values for *R* and *U* are shown in Table 4.3. The *UA* values calculated using Eq. 4.2 are shown in Table 4.2, denoted as "2000 Prescriptive *UA*".

The experimental values of *UA* calculated in Section 4.4 are repeated in Table 4.3 with the *UA* values calculated by using the 2000 IECC method and 2000 Prescriptive method. It should be noted that the experimental values were determined by assuming that all of the thermal energy available from the natural gas entered the building envelope. In fact, because of the furnace thermal efficiency, part of this energy is exhausted. The minimum furnace efficiency specified by the 2000 IECC is 78% so if this efficiency were to be used as a guideline, then the expected *UA* would decrease by 22%. The efficiencies for each home furnace were acquired during the energy audit visits. The furnace efficiencies ranged from 90% to 95.5% and the typical furnace efficiency was 90%. The experimental *UA* values have been modified with the furnace efficiency and are shown in Table 4.3, denoted as "Furnace-modified *UA*".

Table 4.2. Comparison of the experimental *UA* values with *UA* values for code requirements.

Home Number	Age (years)	Style	Experimental *UA* (Btu/h·°F)	Furnace efficiency	Furnace-modified *UA* (Btu/h·°F)	2000 IECC *UA* (Btu/h·°F)	2000 Prescriptive *UA* (Btu/h·°F)
A-1	20	Ranch	474	0.900	426	361	153
A-3	2	Ranch	434	0.920	399	469	198
A-4	7	Ranch	25	0.955	24	424	188
A-6	3	Ranch	348	0.920	320	418	208
A-7	7	Ranch	576	0.900	518	451	181
A-9	7	Ranch	448	0.900	403	389	160
B-1	2	Ranch	430	0.900	387	542	241
B-3	2	Ranch	585	0.900	527	457	195
B-6	9	Ranch	401	0.932	374	448	227
B-8	6	Ranch	623	0.925	576	501	215
C-2	2.5	Ranch	588	0.900	529	476	221
C-3	11	Ranch	466	0.932	434	352	164
C-4	4.5	Ranch	494	0.900	444	426	196
C-7	2	Ranch	298	0.940	280	373	166
C-8	12	Ranch	316	0.900	284	363	164
C-9	2	Ranch	480	0.932	447	432	172
A-2	4	2-Story	713	0.925	659	431	247
B-4	12	2-Story	619	0.900	557	443	226
B-5	2	2-Story	477	0.900	429	426	215
B-9	6.5	2-Story	788	0.900	709	492	268
C-1	2	2-Story	643	0.940	604	578	296
C-5	10	2-Story	687	0.920	658	478	255
C-6	7	2-Story	381	0.900	390	418	208
C-10	12	2-Story	492	0.900	443	504	279
A-5	9	Split Level	395	0.955	377	374	176
A-8	13	Split Level	372	0.920	342	337	140
A-10	9	1-1/2 Story	476	0.900	428	458	221
B-2	2	1-1/2 Story	727	0.900	655	506	282
B-7	8	Split Level	423	0.900	381	278	126
B-10	3	1-1/2 Story	1190	0.900	1071	724	378

Table 4.3. Prescriptive *R* and *U* values obtained from 2000 IECC for the thirty homes.

Home Number	Age (years)	Style	HDD range	Window area/ wall area	U_{window} (Btu/h·ft^2·°F)	$R_{ceiling}$ (h·ft^2·°F/Btu)	R_{wall} (h·ft^2·°F/Btu)
A-1	20	Ranch	7,000-8,499	0.109	0.40	49	21
A-3	2	Ranch	7,000-8,499	0.194	0.30	49	26
A-4	7	Ranch	7,000-8,499	0.115	0.40	49	21
A-6	3	Ranch	7,000-8,499	0.063	0.42	38	16
A-7	7	Ranch	7,000-8,499	0.203	0.30	49	26
A-9	7	Ranch	7,000-8,499	0.175	0.33	49	25
B-1	2	Ranch	6,000-6,4999	0.133	0.35	38	18
B-3	2	Ranch	6,000-6,4999	0.183	0.34	49	22
B-6	9	Ranch	6,000-6,4999	0.096	0.45	38	16
B-8	6	Ranch	6,000-6,4999	0.239	0.25	49	19
C-2	2.5	Ranch	6,000-6,4999	0.104	0.40	38	18
C-3	11	Ranch	6,000-6,4999	0.088	0.45	38	16
C-4	4.5	Ranch	6,000-6,4999	0.148	0.35	38	18
C-7	2	Ranch	6,000-6,4999	0.105	0.40	38	18
C-8	12	Ranch	6,000-6,4999	0.115	0.40	38	18
C-9	2	Ranch	6,000-6,4999	0.201	0.31	49	24
A-2	4	2-Story	7,000-8,499	0.081	0.42	38	16
B-4	12	2-Story	6,000-6,4999	0.135	0.35	38	18
B-5	2	2-Story	6,000-6,4999	0.108	0.40	38	18
B-9	6.5	2-Story	6,000-6,4999	0.123	0.40	38	18
C-1	2	2-Story	6,000-6,4999	0.120	0.40	38	18
C-5	10	2-Story	6,000-6,4999	0.085	0.45	38	16
C-6	7	2-Story	6,000-6,4999	0.102	0.40	38	18
C-10	12	2-Story	6,000-6,4999	0.099	0.45	38	16
A-5	9	Split Level	7,000-8,499	0.105	0.40	49	21
A-8	13	Split Level	7,000-8,499	0.150	0.35	49	21
A-10	9	1-1/2 Story	7,000-8,499	0.146	0.35	49	21
B-2	2	1-1/2 Story	6,000-6,4999	0.080	0.45	38	16
B-7	8	Split Level	6,000-6,4999	0.134	0.35	38	18
B-10	3	1-1/2 Story	6,000-6,4999	0.112	0.40	38	18

A comparison of experimental *UA* values (modified with furnace efficiency) and 2000 IECC *UA* values were used to identify homes that satisfy 2000 IECC standards. Specifically, any home that has an actual *UA* value less than the maximum allowable *UA* based on 2000 IECC criteria is assumed to meet the energy conservation guidelines specified in 2000 IECC. Because of the assumptions and uncertainties associated with calculating both the experimental *UA* and the 2000 IECC *UA* value, it was further assumed that if an experimental *UA* was within 5% of the 2000 IECC *UA*, then it does in fact satisfy the code's criteria. A plot of 2000 IECC *UA* values versus experimental *UA* values in Fig. 4.11 identifies those homes that satisfy the 2000 IECC criteria. The dashed line represents the case when the experimental *UA* is within 5% of the 2000 IECC *UA*, thus accounting for assumptions and uncertainties. An examination of Fig. 4.11 and a comparison of *UA* values in Table 4.2 reveal that sixteen homes satisfy the 2000 IECC standards while 13[1] homes satisfy lesser standards. The aforementioned approach is described in detail in the 2000 IECC (Section 502.2.2) [1] as an alternative method to determine whether a home satisfies the criteria.

The sixteen homes that did satisfy the 2000 IECC are listed in Table 4.4 while the remaining homes are listed in Table 4.5. The tabulated information is also shown in Figs. 4.12-4.14 for the modified *UA* versus floor area, wall area and window area, respectively. It is obvious that the common trend is that homes built to 2000 IECC standards have lower *UA* values compared to homes of lesser standards, with the lower *UA* values representing energy efficient homes. Although many of the newer homes (i.e., three years old or less) meet the criteria, there are almost as many cases where homes less than three years old do not satisfy the 2000 IECC standards. Thus it can be concluded that the age of a home cannot be used as the sole indication of its energy efficiency. Comparing homes in the two tables also shows that satisfying the energy code criteria is not a function of home size or home style in that homes of all sizes and styles appear in both tables. Tables 4.4 and 4.5 also present data for natural gas usage on a total cost basis and cost per floor area. The energy and cost performance of homes that satisfy the 2000 IECC can now be compared to homes built to lesser standards by analyzing the data in graphical format. Figures 4.15-4.17 show natural gas costs versus home size (floor area, wall area and window area, respectively) with the obvious trend being that heating costs are lower for homes built to 2000 IECC standards compared to equivalent sized homes built to lesser standards.

[1] It was determined that the data for home A-4 was misleading because the 2 occupants lived elsewhere during the months of December through March and set their thermostat to 45°F during that period. Thus, home A-4 is not included in further tables or graphs because insufficient data could not provide a conclusive determination as to whether the 7-year old ranch home fell within the 2000 IECC criteria.

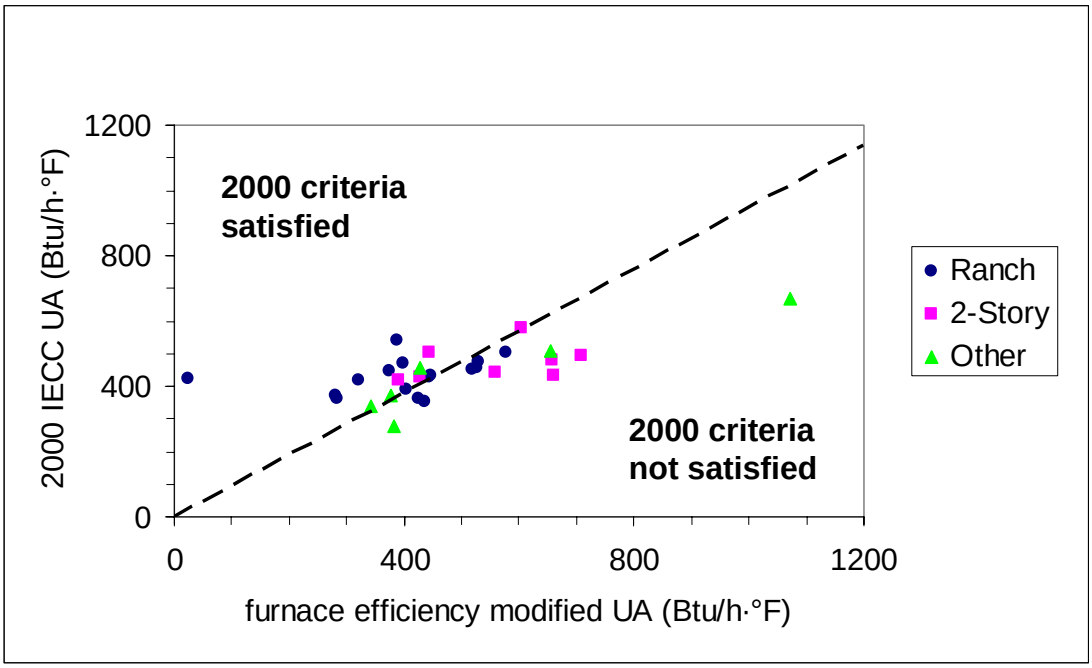

Figure 4.11. The 2000 IECC *UA* versus furnace efficiency modified experimental *UA* for each style of home. The dashed line represents the division between homes that satisfy the 2000 IECC and those homes built to lesser standards.

Table 4.4. Summary of homes that satisfy the 2000 IECC standards.

Home Number	Age (years)	Style	Floor Area (ft^2)	Furnace-modified UA (Btu/h·°F)	Cost ($)	Cost/floor area ($/$ft^2$)
A-3	2	Ranch	1850	**399**	$864	$0.47
A-6	3	Ranch	1800	**320**	$547	$0.30
A-9	7	Ranch	1520	**403**	$753	$0.50
B-1	2	Ranch	2360	**387**	$554	$0.23
B-6	9	Ranch	2072	**374**	$621	$0.30
C-4	4.5	Ranch	1725	**444**	$723	$0.42
C-7	2	Ranch	1536	**280**	$505	$0.33
C-8	12	Ranch	1400	**284**	$518	$0.37
C-9	2	Ranch	1624	**447**	$706	$0.43
B-5	2	2-Story	1775	**429**	$707	$0.40
C-1	2	2-Story	2848	**604**	$740	$0.26
C-6	7	2-Story	1753	**390**	$644	$0.37
C-10	12	2-Story	2041	**443**	$753	$0.37
A-5	9	Split Level	1392	**377**	$707	$0.51
A-8	13	Split Level	1300	**342**	$529	$0.41
A-10	9	1-1/2 Story	1900	**428**	$782	$0.41

Table 4.5. Summary of homes that satisfy standards lesser than 2000 IECC.

Home Number	Age (years)	Style	Floor Area (ft^2)	Furnace-modified UA (Btu/h·°F)	Cost ($)	Cost/floor area ($/$ft^2$)
A-1	20	Ranch	1512	**426**	$705	$0.47
A-7	7	Ranch	2152	**518**	$744	$0.35
B-3	2	Ranch	1675	**527**	$813	$0.49
B-8	6	Ranch	2180	**576**	$862	$0.40
C-2	2.5	Ranch	1972	**529**	$960	$0.49
C-3	11	Ranch	1400	**434**	$928	$0.66
A-2	4	2-Story	2200	**659**	$1,109	$0.50
B-4	12	2-Story	1878	**557**	$790	$0.42
B-9	6.5	2-Story	2300	**709**	$1,218	$0.53
C-5	10	2-Story	2393	**658**	$934	$0.39
B-2	2	1-1/2 Story	2306	**655**	$1,053	$0.46
B-7	8	Split Level	1025	**381**	$551	$0.54
B-10	3	1-1/2 Story	3061	**1071**	$1,696	$0.55

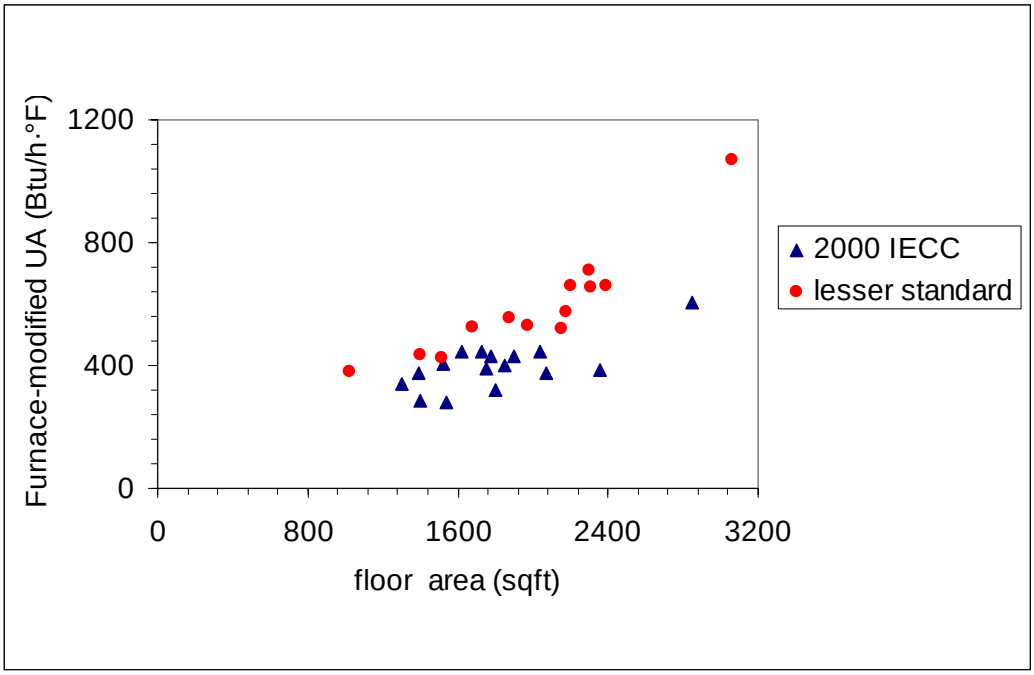

Figure 4.12 Thermal conductance modified with furnace efficiency versus floor area for 2000 IECC and lesser standards.

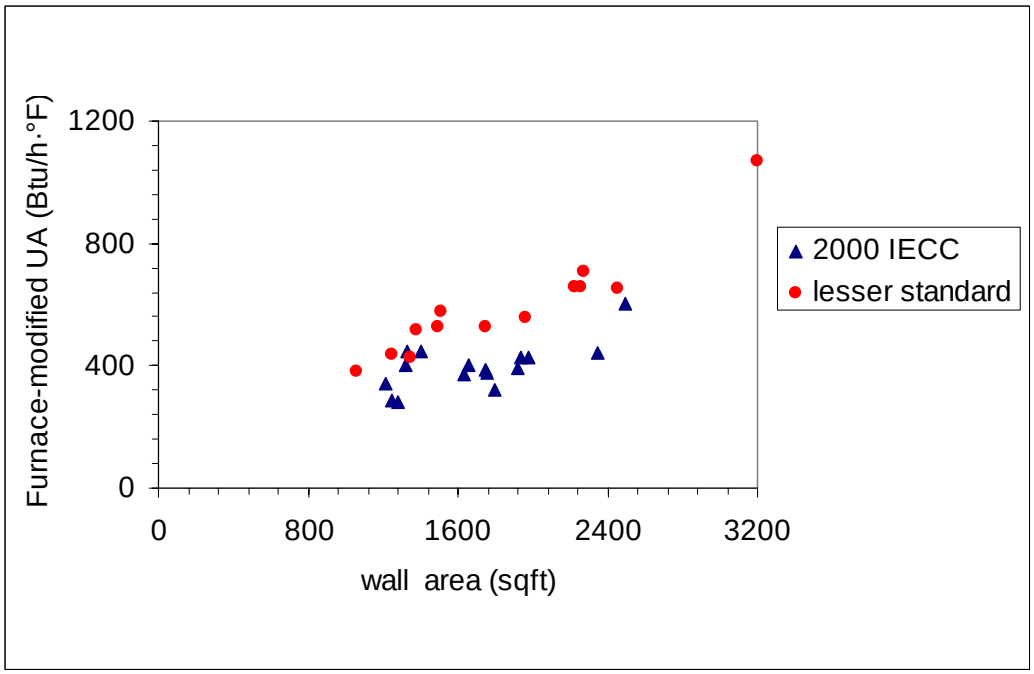

Figure 4.13 Thermal conductance modified with furnace efficiency versus wall area for 2000 IECC and lesser standards.

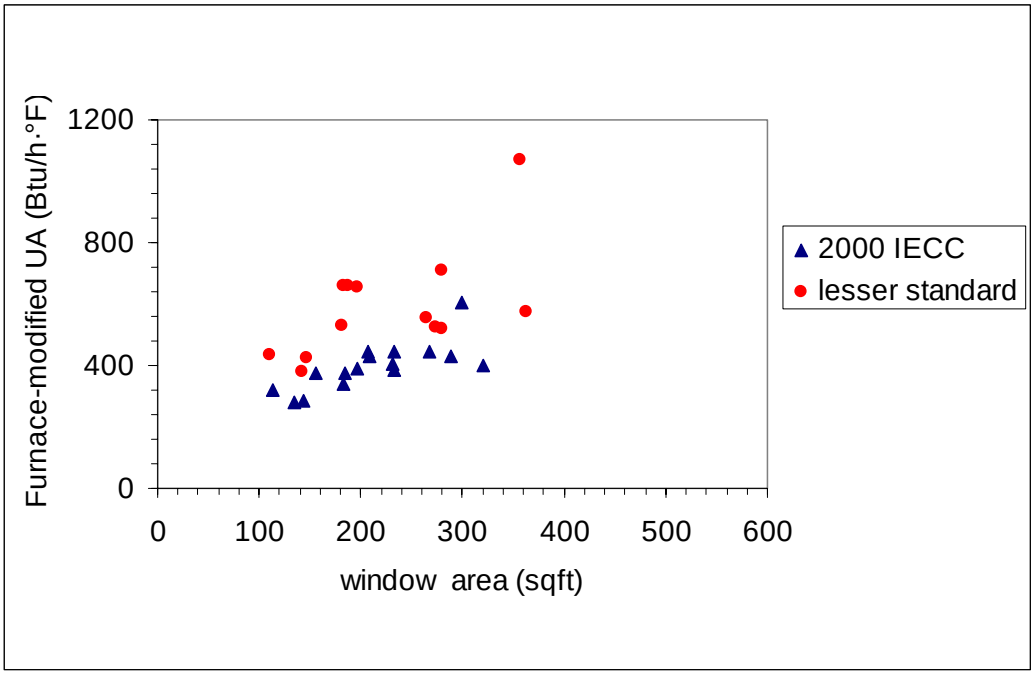

Figure 4.14 Thermal conductance modified with furnace efficiency versus window area for 2000 IECC and lesser standards.

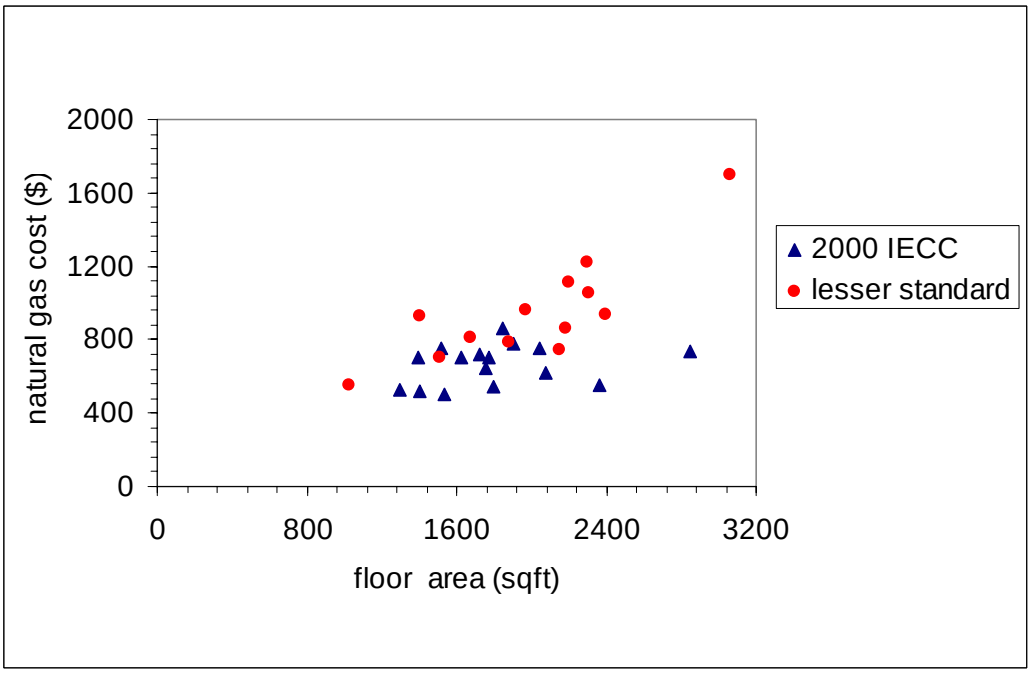

Figure 4.15 Cost of natural gas versus floor area for 2000 IECC and lesser standards.

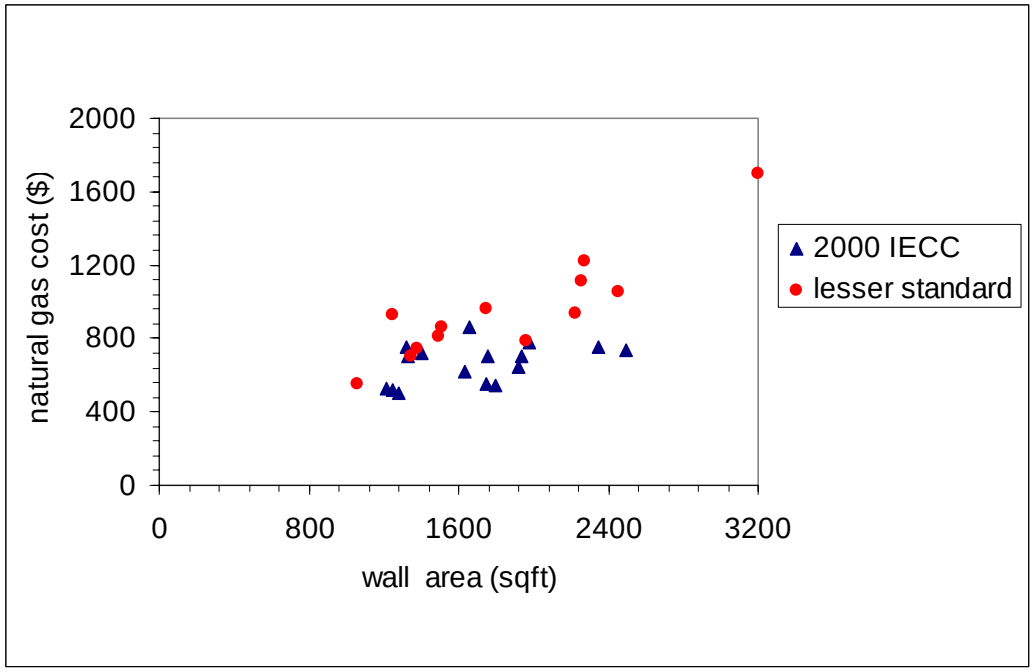

Figure 4.16 Cost of natural gas versus wall area for 2000 IECC and lesser standards.

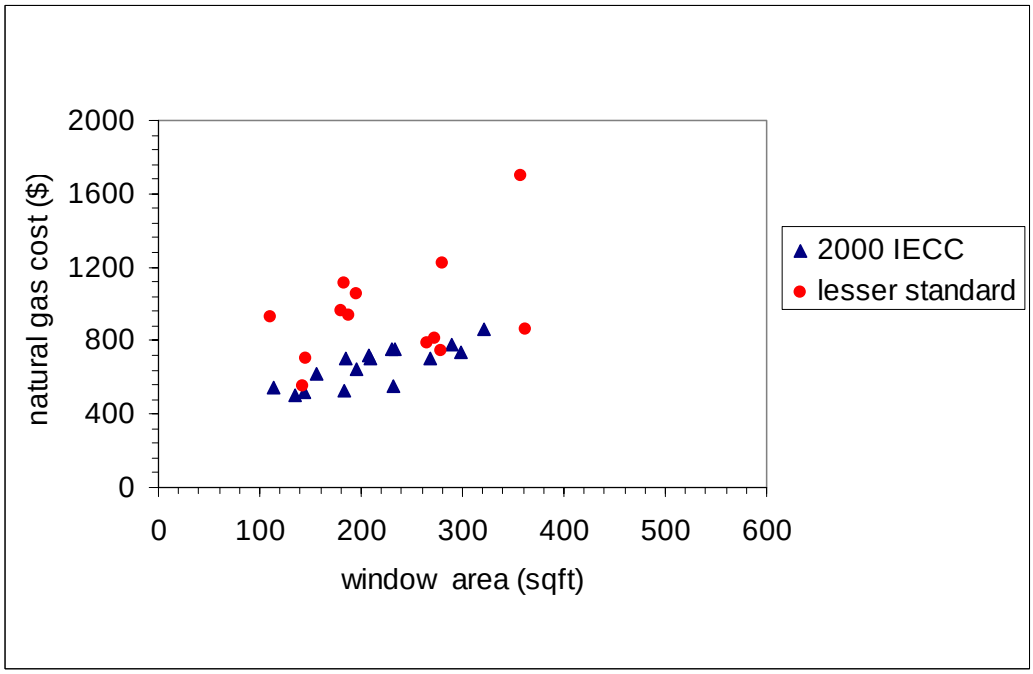

Figure 4.17 Cost of natural gas versus window area for 2000 IECC and lesser standards.

5 Cost for Implementing Building Codes in Iowa

5.1 Approach

The costs to implement energy efficient measures, such as extra insulation in walls and ceilings in order to satisfy requirements specified in the 2000 IECC, were determined for several sizes and styles of homes. This information will provide valuable guidance to homeowners who are planning to build a new home and are in the process of deciding whether to build according to either 2000 IECC, 1992 MEC or lesser standards.

To address the questions of added cost to satisfy energy code requirements, a cost analysis was performed for different levels of insulation in three home styles. These homes are divided into three categories: 1) a home that satisfies only minimum insulation requirements and is not energy efficient, henceforth referred to as "low efficiency", 2) a home that often meets the required insulation levels when codes are not mandated or emphasized, henceforth referred to as "current practice", and 3) a home that meets the insulation requirements according to the 2000 IECC, henceforth referred to as "2000 IECC".

A low efficiency home was considered to be a home that had *R*-19 rated blown fiberglass insulation in the ceiling, *R*-11 rated fiberglass blanket insulation in the walls, and no insulation around the ducts. In addition, the window *U*-value was 0.5 Btu/h·ft^2·°F and none of the duct seams were sealed. A home built to current practices was considered to be a home that had *R*-30 rated blown fiberglass insulation in the ceiling, *R*-13 rated fiberglass blanket insulation in the walls, and no insulation around the ducts. In addition, the window *U*-value was the same as the low efficiency home and none of the duct seams were sealed.

The energy conservation measures of concern for this cost analysis were the insulation requirements for the ceilings, walls, windows and ducts. The analysis compared the difference in the costs of the insulation to upgrade the low efficiency homes and current practice homes to the energy efficiency level of homes built in accordance with the 2000 IECC. The cost for duct sealing was also considered for this analysis since existing homes are not normally sealed, although the 1992 MEC and 2000 IECC mandate duct sealing.

For all of the homes used in the analysis, it was assumed that the windows (which have a glazing wall ratio of 0.1) accounted for 15% of the gross area of the walls and that the ceiling height was 8 ft for all levels. The total area of the walls that required insulation was found by subtracting the window area from the gross wall area. For this analysis, the dimensions of the ducts that were in unconditioned spaces were 15 inches by 3 inches. The *R*-5 rated duct wrap insulation needed for the ducts in unconditioned spaces is 1½ inches thick. When the duct was wrapped with duct-wrap insulation, it had the dimensions 18 inches by 6 inches. Since the duct was 6 inches wide with the insulation, the duct can fit in-between 6 inch walls.

5.2 Types of Homes

The styles of homes that were used in this differential cost analysis were ranch, 2-story and split-level. Additionally, each of these three homes was modeled using five different floor area sizes.

The five floor sizes used in the analysis are: 1000 ft^2, 1500 ft^2, 2000 ft^2, 2500 ft^2, and 3000 ft^2. A description of the model for each home style is presented next. Also presented is the methodology for determining home characteristics, such as walls and window area, duct length and duct area, which is used to determine insulation requirements.

5.2.1 Ranch Style Home

The ranch home used in this analysis has the main floor directly above the heated basement (refer to Fig. A.1). To demonstrate how the various parameters were determined for each of the five sizes of ranch homes, a 1500 ft^2 home was selected for the detailed calculations presented below. A 1500 ft^2 ranch home has a main floor area of 1500 ft^2 and a ceiling of the same area. The dimensions of the homes, such as the length and width, were calculated assuming that the length of the home is twice the width of the home.

For example:

$$L \times W = 1500 \text{ ft}^2 \tag{5.1}$$

where L is the length of the home and W is the width of the home. Since $L = 2 \times W$, Eq. 5.1 can be written as:

$$2W \times W = 1500 \text{ ft}^2$$

or

$$2W^2 = 1500 \text{ ft}^2 \tag{5.2}$$

Rearranging Eq. 5.2 to solve for home width, W, results in:

$$W = \sqrt{\frac{1500 \text{ ft}^2}{2}} = 27 \text{ ft}$$

and therefore, the home length L is 55 ft. Note that the home dimensions have been rounded to a whole number. The total wall area can be calculated by using the known width and heights, assuming the walls are 8 ft high, i.e., distance from floor to ceiling. Table 5.1 contains the various dimensions, based on sample calculations using Eq. 5.2, for different size ranch homes.

Table 5.1. Characteristics of different-sized ranch-style homes.

Floor Area (ft^2)	Number of Levels	Ceiling Area (ft^2)	Length (ft)	Width (ft)	Wall Area (ft^2)	Window Area (ft^2)	Wall Area - Window Area (ft^2)	Duct Length (ft)	Duct Area (ft^2)	Glazing Area, ft^2
1000	1	1000	45	22	1073	161	912	N/A	N/A	107
1500	1	1500	55	27	1315	197	1117	N/A	N/A	132
2000	1	2000	63	32	1518	228	1290	N/A	N/A	152
2500	1	2500	71	35	1697	255	1442	N/A	N/A	170
3000	1	3000	77	39	1859	279	1580	N/A	N/A	186

Since the ranch home has a heated basement and only one level, there is no need to place ducts in unconditioned spaces. The column titled "Duct Length, ft" in Table 5.1 is the total length of duct work, which is located in unconditioned spaces (e.g., an attic or an unconditioned basement), that needs to be insulated. However, ducts are not present in unconditioned spaces for the ranch-style home; therefore, an N/A (not applicable) was placed in this column.

5.2.2 2-Story Style Homes

The 2-story home used in this analysis has three levels, namely a basement, a main level directly above the basement, and a second floor directly above the main level (refer to Figs. A.2a). Similar to the ranch home, the basement of the 2-story home was also heated. To demonstrate how the various parameters were determined for each of the five sizes of 2-story homes, a 1500 ft^2 home was selected for the detailed calculations presented below. The 1500 ft^2 2-story home has a main-level floor area of 750 ft^2 and a second-level floor area of 750 ft^2, which also means that each ceiling has an area of 750 ft^2. The dimensions of the 2-story homes, such as the length and the width, were calculated assuming that the length of the home is equal to the width of the home.

For example:

$$L \times W = 750 \text{ ft}^2 \tag{5.3}$$

where L is the length of the home and W is the width of the home. Since $L = W$, Eq. 5.3 can be written as:

$$W^2 = 750 \text{ ft}^2 \tag{5.4}$$

Rearranging Eq. 5.4 to solve for home width, W, results in:

$$W = \sqrt{750 \text{ ft}^2} = 27 \text{ ft}$$

and therefore, the home length L is 27 ft. As with the ranch home, the dimensions have been rounded off to the nearest whole number. Since the length and width of the home have been calculated and the wall heights on the main level and second level are 8 ft high, the total wall area for the home can also be calculated.

Unlike the ranch home that did not require insulated ducts, the 2000 IECC requires that the ducting to the second level be insulated. A procedure is presented in the following paragraph to determine the uninsulated and insulated duct length, and then calculations for duct length are presented for a 1500 ft^2 home. Since the second floor is a conditioned space, a supply duct has to be placed in the exterior wall from the basement to the second floor. In addition, the duct has to travel through the floor between the main floor and second floor so that heating and cooling can be provided to all the rooms on the second floor. Figures A.2a-b are schematics of the layout of the 2-story home, which illustrate the placement of the unconditioned spaces (shaded in grey) in relation to the floors and rooms. It is assumed that the supply duct runs vertically through the exterior wall, a length of about 8 ft from the basement level to the second floor, and then it runs

between the main floor and the second floor, for a length of ¾ of the width of the home. Finally, it branches off to a register located in each of the rooms on the second floor (refer to Fig. A.2a). It is also assumed that the second level has 4 rooms and that each room has one register. The branch from the supply duct to each of these registers is assumed to be 1 ft long (refer to Fig. A.2b). The ductwork located in the exterior wall and between the main and second floors is confined in an unconditioned space and, according to the 2000 IECC, needs to be insulated with *R*-5 rated duct wrap insulation.

An example of calculating the area of the insulated duct for a 2-story home that has 1500 ft^2 of floor area (W = 27 ft) is presented next. The total length of duct work for an unconditioned space can be found by using the following equation:

$$L_{Duct} = ¾\ W + 8\ ft + 4\ ft \tag{5.5}$$

where L_{Duct} is the duct length and W is the width of the home. Using Eq. 5.5 and known dimensions, the resulting duct length for the 1500 ft^2 home is 32.25 ft. Therefore, the amount of duct-wrap insulation needed is about 97 ft^2. Table 7.2 contains the various dimensions based on calculations using Eq. 5.5 for the five sizes of 2-story homes.

Table 5.2. Characteristics of different-sized 2-story homes.

Floor Area (ft^2)	Number of Levels	Ceiling Area (ft^2)	Length (ft)	Width (ft)	Wall Area (ft^2)	Window Area (ft^2)	Wall Area – Window Area (ft^2)	Duct Length (ft)	Duct Area (ft^2)	Glazing Area (ft^2)
1000	2	500	22	22	1431	215	1216	29	86	143
1500	2	750	27	27	1753	263	1490	33	98	175
2000	2	1000	32	32	2024	304	1720	36	107	202
2500	2	1250	35	35	2263	339	1923	39	116	226
3000	2	1500	39	39	2479	372	2107	41	123	248

5.2.3 Split-Level Style Homes

The split-level home used in this analysis has three levels, a lower level that is half underground, a main level that is adjacent to the lower level but completely above ground, and an upper level that is directly above the lower level (refer to Figs. A.3a.). All three levels of the split level home were heated. To demonstrate how the various parameters were determined for each of the five sizes of split-level homes, a 1500 ft^2 home was selected for the detailed calculations presented below. The 1500 ft^2 split-level home has a main level floor area of 500 ft^2, a lower-level floor area of 500 ft^2, and an upper-level floor area of 500 ft^2. The split-level arrangement results in a total ceiling area of 1000 ft^2.

The dimensions of each of the levels, such as the length and width, were calculated assuming that the length of each level is equal to the width of each level. For example:

$$L \times W = 500 \text{ ft}^2 \quad (5.6)$$

where L is the length of the level and W is the width of the level. Since $L = W$, Eq. 5.6 can be written as:

$$W^2 = 500 \text{ ft}^2 \quad (5.7)$$

Rearranging Eq. 5.7 to solve for level width, W, results in:

$$W = \sqrt{500 \text{ ft}^2} = 22 \text{ ft}$$

Since $L = W$, then the level length, L, is 22 ft and the dimensions have been rounded off to the nearest whole number. Once the length and width of each level have been calculated, assuming the walls on the lower level, upper level, and main level are all 8 ft high, the total wall area for the home can also be calculated.

Unlike the ranch home that did not require insulated ducts, the 2000 IECC requires that the ducting to the main level be insulated. Hence, a procedure is presented below to determine the uninsulated and insulated duct length, and then calculations for duct length are presented later for a 1500 ft^2 home.

Since the main floor is a conditioned space, a supply duct has to be placed under the floor of the main level between the ground and the main level so that heating and cooling can be provided to all the rooms on the main level (refer to Fig. A.3a.). It is assumed that the supply duct runs between the ground and the main level for a length of ¾ of the width of the main level. Finally, it branches off to a register located in each of the rooms on the main level (refer to Fig. A.3b). It is also assumed that the main level has 4 rooms and that each room has one register. The branch from the supply duct to each of these registers was assumed to be 3 ft^2 long. The ductwork located between the main level and the ground is confined in an unconfined space, and according to the 2000 IECC, needs to be insulated with R-5 rated duct wrap insulation.

An example of calculating the area of the insulated duct for a split-level home that has 1500 ft^2 of floor area, which corresponds to a level width of 22 ft, is presented next. The total length of duct work that is in unconditioned spaces can be found by using the following equation:

$$L_{\text{Duct}} = ¾\ W + 8 \text{ ft} + 4 \text{ ft} \quad (5.8)$$

where L_{Duct} is the duct length and W is the width of the main level. Using Eq. 5.8 and the known information, the resulting duct length for the 1500 ft^2 home is 28.5 ft. Therefore, the amount of duct wrap insulation needed is about 86 ft^2. Table 5.3 contains the various dimensions based on the above calculations of the five different sized split-level homes.

Table 5.3. Characteristics of different-sized split-level homes

Floor Area (ft^2)	Number of Levels	Ceiling Area (ft^2)	Length (ft)	Width (ft)	Wall Area (ft^2)	Window Area (ft^2)	Wall Area – Window Area (ft^2)	Duct Length (ft)	Duct Area (ft^2)	Glazing Area (ft^2)
1000	3	667	18	18	1753	263	1490	26	77	175
1500	3	1000	22	22	2147	322	1825	29	86	215
2000	3	1333	26	26	2479	372	2107	31	94	248
2500	3	1667	29	29	2771	416	2356	34	101	277
3000	3	2000	32	32	3036	455	2580	36	107	304

6 Unit Cost of Energy Efficient Upgrades

6.1 Ceiling Insulation

The cost of blown fiberglass insulation for the ceiling was taken from R.S. Means [9], and the costs are shown in Table 6.1 for four different insulation levels. Since the R.S. Means was published in 1996, the cost for the insulation has been adjusted for an inflation rate of 2% per year to reflect the prices for the year 2002. Since the costs for *R*-38 or *R*-49 could not be found in R.S. Means, the costs for *R*-37 and *R*-48 were estimated. For example, *R*-37 was estimated by adding the costs of *R*-26 and *R*-11, and the cost of *R*-48 was estimated by doubling the cost of *R*-11 and then adding it to the cost for *R*-26.

Table 6.1. Ceiling-blown fiberglass insulation costs.

Rating	Cost per ft^2 (1996)	Cost per ft^2 (2002)
R-19	$0.48	$0.54
R-30	$0.78	$0.88
R-38 (R-37)	$1.01	$1.14
R-49 (R-48)	$1.31	$1.48

Figure 6.1 shows the relationship between the *R*-value and the cost of the fiberglass blown insulation, which reflects 2002 prices. As expected, the cost of insulating the attic increases with the amount of insulation and hence *R*-value.

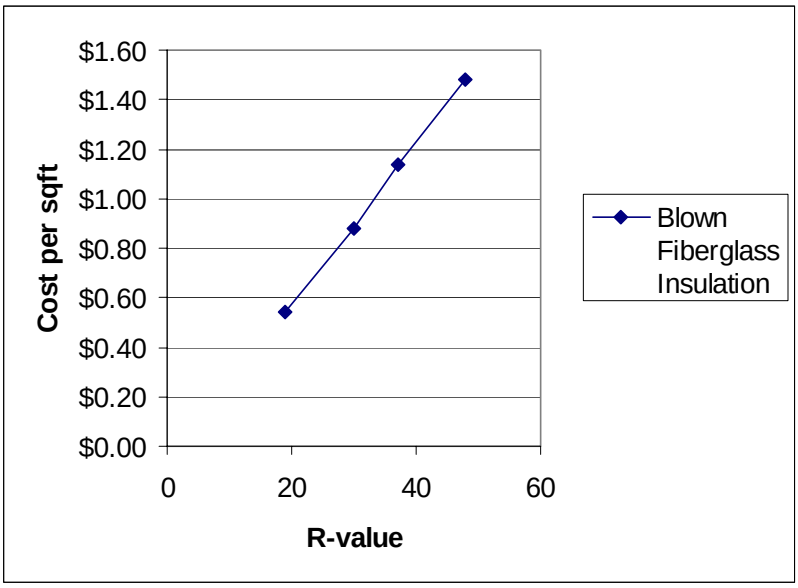

Figure 6.1. Cost per square foot of blown fiberglass insulation versus *R*-value.

6.2 Wall Insulation

The cost of fiberglass blanket insulation for the walls was taken from R.S. Means [9], and the costs are shown in Table 6.2 for four different insulation levels. As before, since R.S. Means was published in 1996, the cost for the insulation has been adjusted for an inflation rate of 2% per year to reflect the prices for the year 2002. The costs for *R*-13 and *R*-16 were not provided in R.S. Means, and therefore, their costs were estimated through interpolation. It should be noted that the abbreviation "est." represents estimated costs.

Table 6.2. Blanket Fiberglass Insulation Costs

Rating	Cost per ft^2 (1996)	Cost per ft^2 (2002)
R-11	$0.28	$0.32
R-13	$0.30 (est.)	$0.34
R-16	$0.33 (est.)	$0.37
R-18 (R-19)	$0.36	$0.41

Figure 6.2 shows the relationship between the *R*-value and the cost of the fiberglass blanket insulation, which reflects 2002 prices. It can be seen that there is a linear relationship between *R*-values and cost.

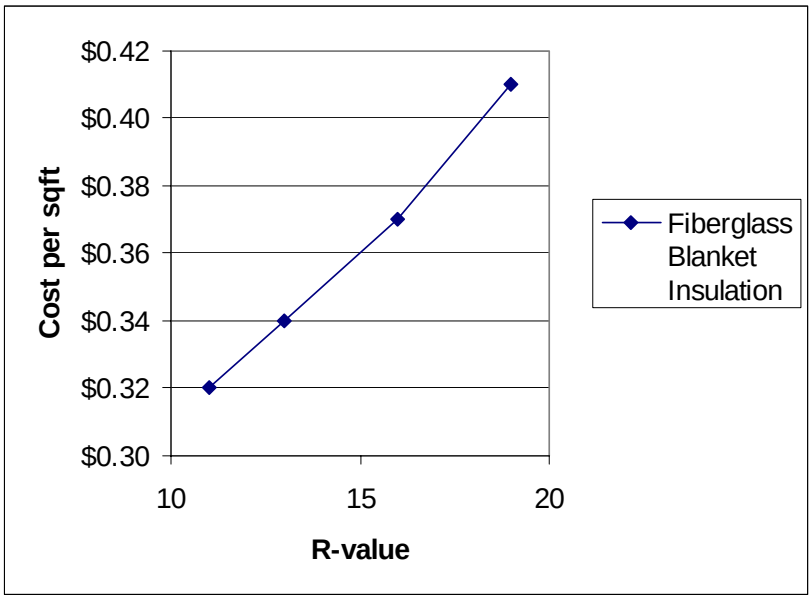

Figure 6.2. Cost per square foot of fiberglass blanket insulation versus *R*-value.

6.3 Duct Insulation and Sealing

The installed cost for 1 ½ inches of duct wrap insulation with an *R*-value of 5 is $1.92/ft^2 as provided by R.S. Means [10]. Since this cost came from a 2000 publication, the cost for the insulation has been adjusted for an inflation rate of 2% per year to reflect the price for the year 2002, which is $2.00/ft^2. A study by Hammon and Modera [11] reported a $214 cost for improved duct sealing in new homes.

6.4 Window *U*-values

Home built to 2000 IECC standards are considered to have windows with *U*-values of 0.35 Btu/h·ft^2·°F, while current practice homes and low efficiency homes are assumed to have *U*-value of 0.5 Btu/h·ft^2·°F. The additional cost of purchasing the lower *U*-value windows for the 2000 IECC was estimated by Lucas [12,13] to be $0.63/ft^2 based on 1996. Increasing this value to reflect the year 2002 based on an inflation rate of 2% per year, results in the added cost for more efficient windows to be $0.73/ft^2.

7 Costs of Energy Efficient Upgrades

Using the home dimensions and unit costs for energy efficient upgrades determined in Section 6, the cost of upgrading low efficiency homes and current practice homes to the standard of homes built in accordance with the 2000 IECC was determined for all thirty homes used in this study. As noted previously, it was assumed for the analysis that the windows accounted for 15% of the gross area of the walls and that the ceiling height was 8 ft for all levels. The total area of the walls that would need to be insulated was found by subtracting the window area from the gross wall area.

Tables 7.1-7.3 show the costs to upgrade (i.e., cost difference) insulation in low efficiency homes to the requirements of the 2000 IECC for a ranch-style, 2-story, and split-level home, respectively. Tables 7.4-7.6 show the costs to upgrade current practice homes for the same three home styles to the requirements of 2000 IECC. These costs are shown for different home styles as well as different sizes ranging from 1000 to 3000 ft^2. The cost difference information in each of the tables is also presented in Figs. 7.1-7.6. Recall that ranch-style homes do not require ducts to be insulated because the ducts do not occupy unconditioned spaces. It is interesting to note that ceiling insulation is the most costly upgrade and that the upgrade cost is substantially lower for the current practice homes compared to low efficiency homes.

Table 7.1. Cost difference between low efficiency and 2000 IECC for a ranch home.

Floor Area (ft^2)	Duct Sealing	Duct Insulating	Ceiling R-19 to R-38	Walls R-11 to R-18	Glazing U = 0.50 to U = 0.35	Total Cost
1000	$214	$0	$600	$82	$78	$974
2000	$214	$0	$1,200	$116	$111	$1,641
3000	$214	$0	$1,800	$142	$136	$2,292

Table 7.2. Cost difference between low efficiency and 2000 IECC for a 2-story home.

Floor Area (ft^2)	Duct Sealing	Duct Insulating	Ceiling R-19 to R-38	Walls R-11 to R-18	Glazing U = 0.50 to U = 0.35	Total Cost
1000	$214	$173	$300	$109	$104	$901
2000	$214	$214	$600	$155	$148	$1,331
3000	$214	$246	$900	$190	$181	$1,731

Table 7.3. Cost difference between low efficiency and 2000 IECC for a split-level home.

Floor Area (ft^2)	Duct Sealing	Duct Insulating	Ceiling R-19 to R-38	Walls R-11 to R-18	Glazing U = 0.50 to U = 0.35	Total Cost
1000	$214	$154	$400	$134	$128	$1,030
2000	$214	$188	$800	$190	$181	$1,573
3000	$214	$214	$1,200	$232	$222	$2,082

Table 7.4. Difference in cost between current practice and 2000 IECC for a ranch home.

Floor Area (ft^2)	Duct Sealing	Duct Insulating	Ceiling R-30 to R-38	Walls R-13 to R-18	Glazing U = 0.50 to U = 0.35	Total Cost
1000	$214	$0	$260	$64	$78	$616
2000	$214	$0	$520	$90	$111	$935
3000	$214	$0	$780	$111	$136	$1,240

Table 7.5. Cost difference between current practice and 2000 IECC for a 2-Story home.

Floor Area (ft^2)	Duct Sealing	Duct Insulating	Ceiling R-30 to R-38	Walls R-13 to R-18	Glazing U = 0.50 to U = 0.35	Total Cost
1000	$214	$173	$130	$85	$104	$706
2000	$214	$214	$260	$120	$148	$956
3000	$214	$246	$390	$147	$181	$1,179

Table 7.6. Cost difference between current practice and 2000 IECC for a split-level home.

Floor Area (ft^2)	Duct Sealing	Duct Insulating	Ceiling R-30 to R-38	Walls R-13 to R-18	Glazing U = 0.50 to U = 0.35	Total Cost
1000	$214	$154	$173	$104	$128	$774
2000	$214	$188	$347	$147	$181	$1,077
3000	$214	$214	$520	$181	$222	$1,351

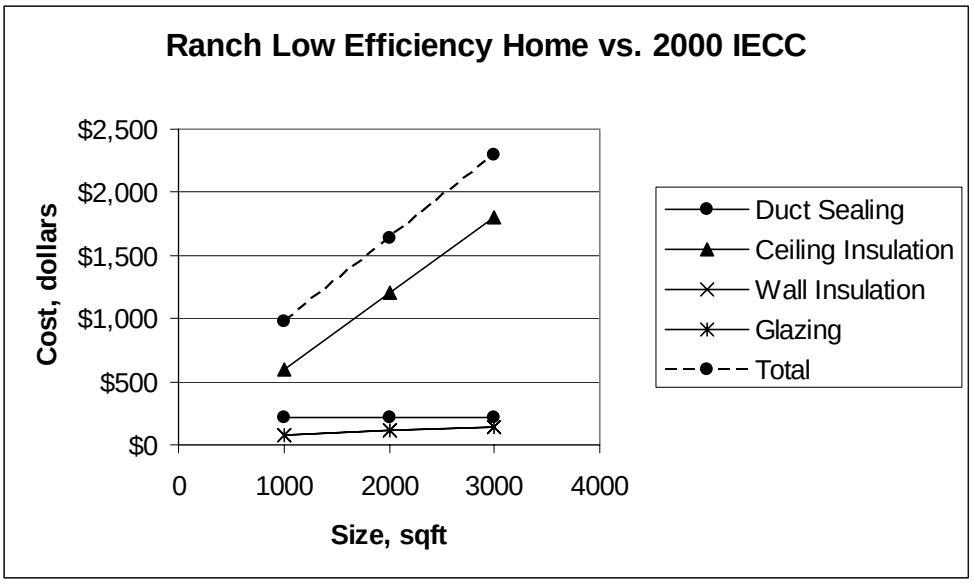

Figure 7.1. Cost difference between low efficiency and 2000 IECC for upgrades to duct sealing and ceiling/wall insulation for a ranch home.

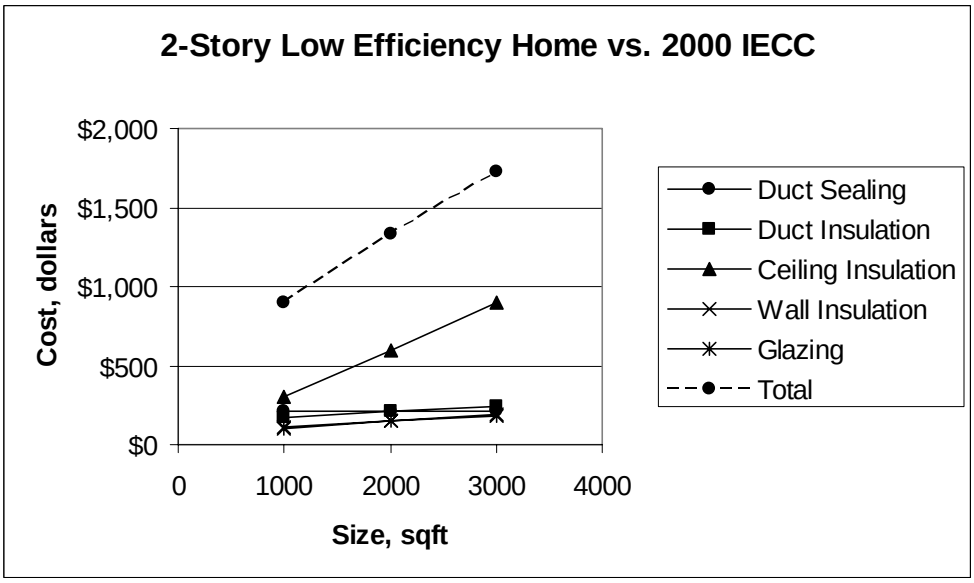

Figure 7.2. Cost difference between low efficiency and 2000 IECC for upgrades to duct sealing and duct/ceiling/wall insulation for a 2-story home.

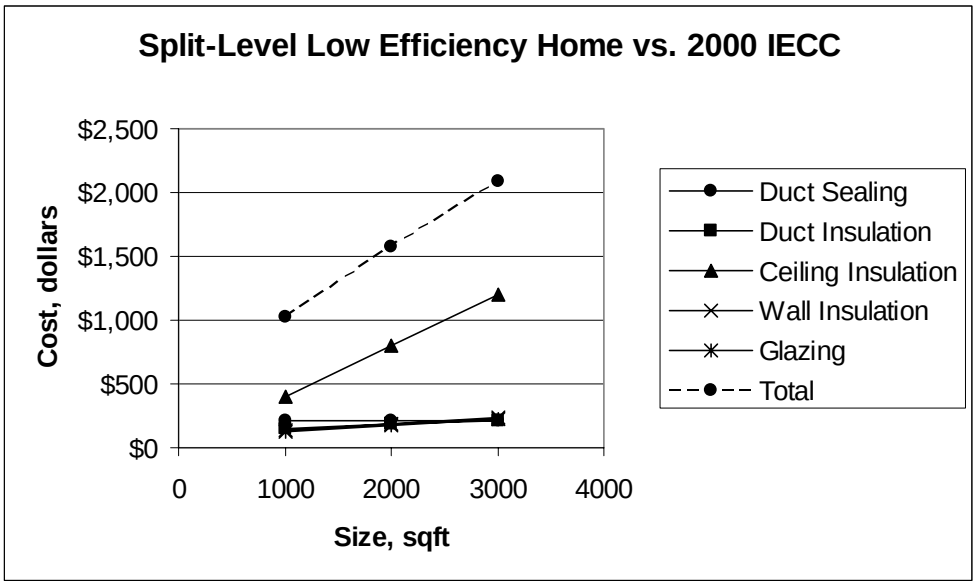

Figure 7.3. Cost difference between low efficiency and 2000 IECC for upgrades to duct sealing and duct/ceiling/wall insulation for a split-level home.

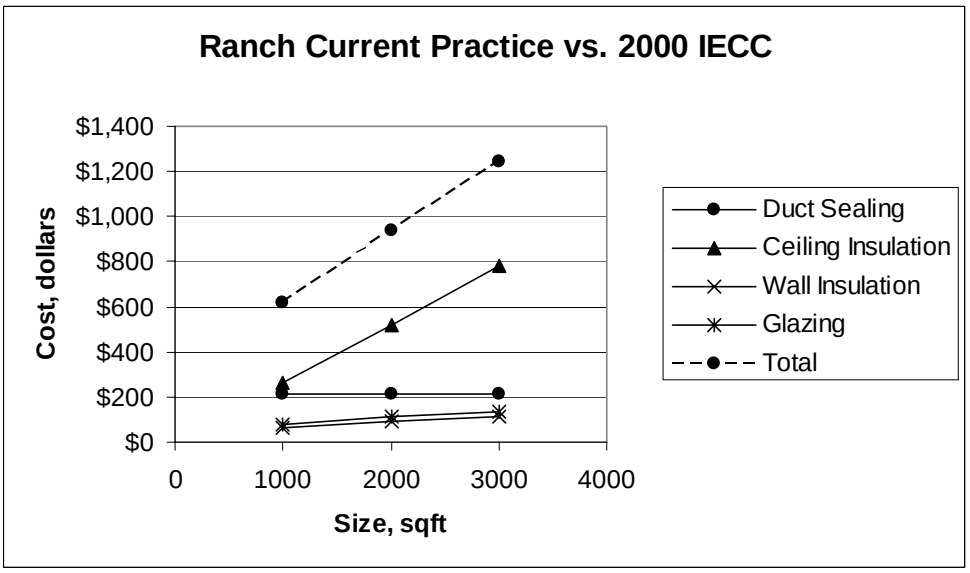

Figure 7.4. Cost difference between current practice and 2000 IECC for upgrades to duct sealing and ceiling/wall insulation for a ranch home.

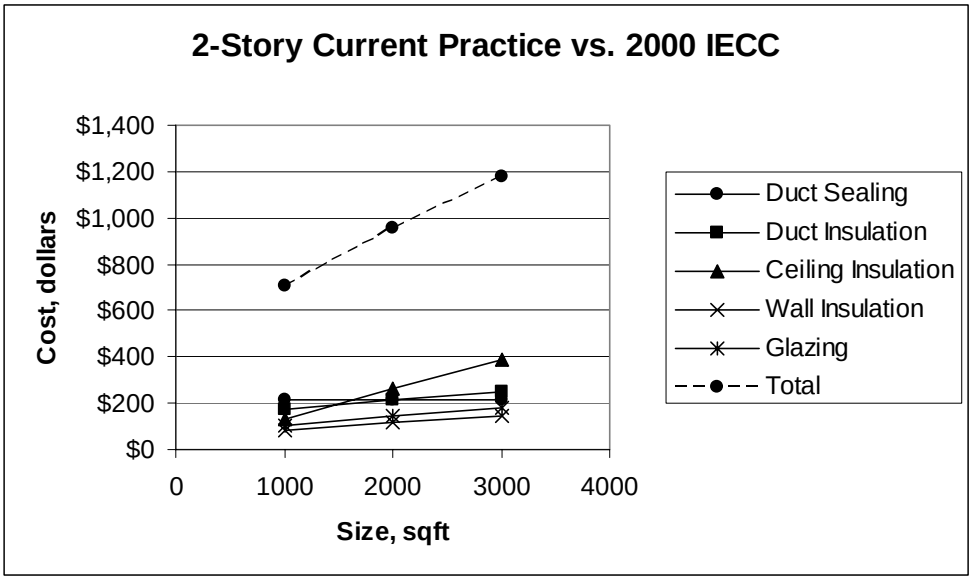

Figure 7.5. Cost difference between current practice and 2000 IECC for upgrades to duct sealing and duct/ceiling/wall insulation for a 2-Story home.

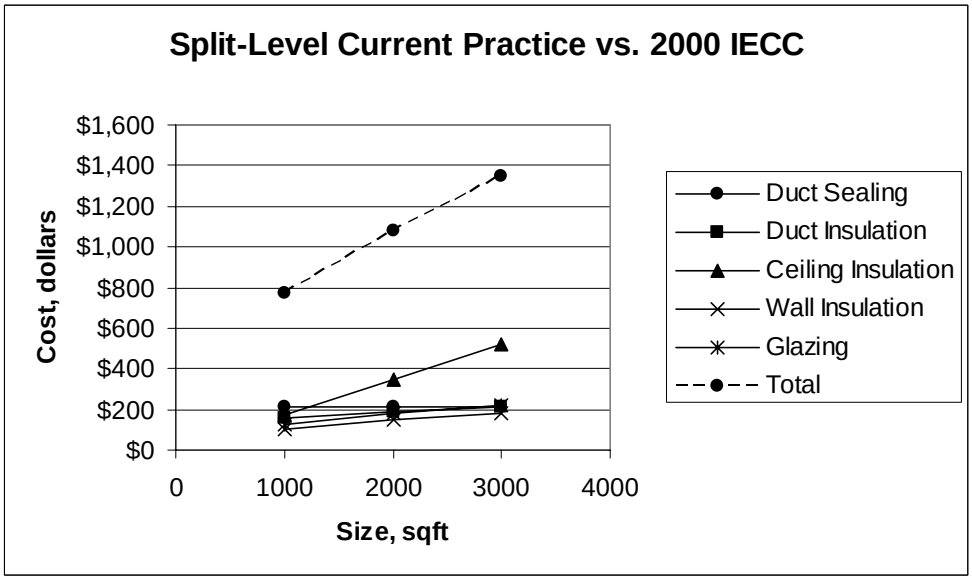

Figure 7.6. Cost difference between current practice and 2000 IECC for upgrades to duct sealing and duct/ceiling/wall insulation for a split-level home.

Using the values from Tables 7.1-7.3, Fig. 7.7 shows the total cost to upgrade low efficiency homes to 2000 IECC for each size and style of home. Figure 7.8 is a similar plot showing the cost to upgrade current practice homes to 2000 IECC. As expected, it is more costly to upgrade the low efficiency homes as opposed to the current practice homes.

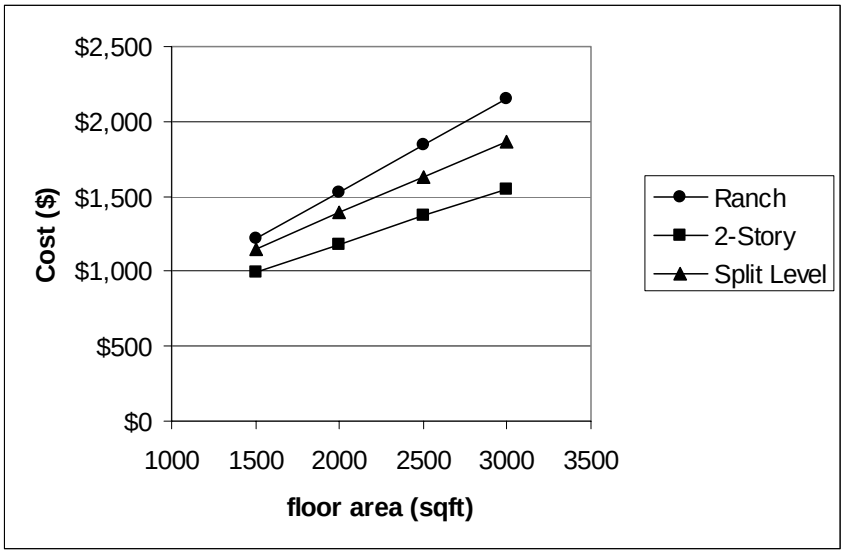

Figure 7.7. Comparison of cost differences between a low energy efficiency home and a 2000 IECC home for four sizes of houses and three home styles.

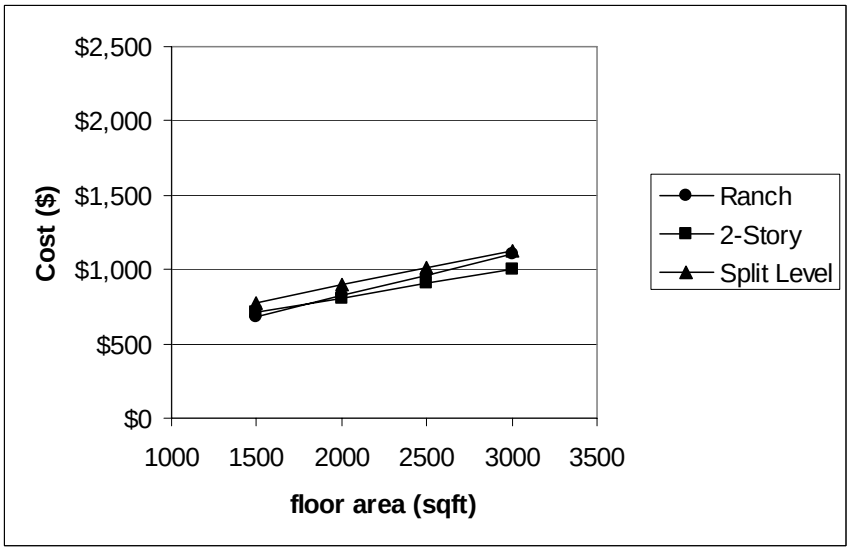

Figure 7.8. Comparison of cost differences between a current practice home and a 2000 IECC home for four sizes of houses and three home styles.

8 Energy Cost Savings with 2000 IECC Homes

8.1 Overview

Building homes that are energy efficient can reduce energy consumption and save a homeowner money, even when the added cost of building a home to higher code standards is considered. These financial savings are evaluated in this section by using the Energy 10 code to model different home types, styles and sizes. The results should provide the motivation for homeowners and home builders to purchase and construct homes that meet 2000 IECC standards.

8.2 Description of Energy 10

Energy 10 is a software package that takes the whole-building design approach for designing low-energy buildings [14]. It can be used to design buildings that are 10,000 ft^2 or less, and it can be used during the early design phases for larger buildings. Energy 10 was developed by the building industry through a team of architects, engineers, builders, and utility representatives from the Sustainable Buildings Industry Council (SBIC), the National Renewable Energy Laboratory (NREL), Lawrence Berkeley National Laboratory (LBNL), and the Berkeley Solar Group (BSG). The Energy 10 project was funded by the Department of Energy (DOE). The software is user-friendly and requires minimal time for a user to become proficient.

When using Energy 10 to design a building, a "reference case building" is initially used to define the design building characteristics. The reference building is assigned as building number one; and it is initialized as a rectangular shoebox design with one or two thermal zones. Two thermal zones are provided for building designs where the temperature in one zone might be different from the other zone. Each of the two thermal zones is assigned a separate HVAC system, and the two HVAC systems do not need to be of the same type. Also, both thermal zones share a common wall. The characteristics of each of the two zones, such as the dimensions, wall construction, roof construction, window type, glazing to wall ratio, floor type, type of building, number of floors, and thermostat temperature settings, can be entered into Energy 10 for the reference case.

After all of the characteristics for the reference building (i.e., building number one), have been input into Energy 10, the software generates a "low energy case building" that can be compared to the reference case. The low energy case is assigned as building number two. The low energy building will have the same dimensions as the reference building, such as floor area, window area, wall area, and roof area, however it will have different building characteristics that will make the low energy building more energy efficient than the reference building. Examples of these building characteristics are wall construction, type of windows, and roof construction.

When defining the reference case characteristics of a ranch-style, two-story, or 1-1/2 story home in Energy 10, only one thermal zone was required since no other buildings, other than a garage, were attached to these homes. A ranch home was defined as having only one floor, and 2-story and 1-1/2-story homes were defined as having two floors. A split-level home was defined as having two thermal zones for the reference case since one part of the home is adjacent to the

other part of the home. Thus, the model for a split-level home was based on specifying zone #1 with two levels, namely one level being a basement and the second level directly above the basement, and specifying zone #2 with only one floor without a basement. The reference case characteristics for the split-level home also used two zones, and the characteristics for zone #2 were consistent with zone #1because each zone required the same type of HVAC system.

After both the reference case and the low energy case were initially defined, each of the two buildings was modified individually. Some of the possible modifications include changes to the wall construction, the roof construction, the *U*-factor of the windows, the HVAC efficiency, *R*-value for the walls and the infiltration rate. Energy 10 also takes into consideration additional heat gains such as electrical loads, a hot water heater, or any other sources of heat, while performing simulations for the two buildings. Other options that can be entered into Energy 10 include location of the home, fuel cost in dollars per therm, electric rate in dollars per kilowatt-hour, and electrical demand in dollars per kilowatt.

After the two buildings are defined and the necessary modifications are made, Energy 10 then performs hour-by-hour simulations for a typical year to estimate the performance of each of the two buildings. These simulations are performed for the two buildings based on weather information for the city in which the buildings reside. Data that can be retrieved from the simulations include annual, monthly, daily, and hourly energy use and energy cost. The data for energy use and energy cost is provided in the form of line graphs or bar graphs, where the energy use and energy cost can be compared between the reference case building and the low energy case building. The energy use data shows the amount of energy used for heating, cooling, and lighting the home. The energy cost data shows the cost for gas and electricity to meet all of the home energy demands.

The major advantage of Energy 10 is that it is a comprehensive building energy analysis tool that accounts for all of the heating and cooling loads experienced by a building, with the user being allowed to define the building characteristics. In addition, the Energy 10 model allows the user to specify the home location in order to access local weather data. Another major advantage of using Energy 10 is that it has been designed specifically to perform energy analyses on smaller buildings (i.e., less than 10,000 ft^2) making it an ideal design tool for single-family residences. One disadvantage of Energy 10 is that it can not give the user a graphic display of the building. However, a future version of Energy 10 will include a graphic input that will allow a user to draw the building on the screen.

8.3 Energy 10 Program Inputs

A list of the parameters and actual values (cited parenthetically) that were input into Energy 10 for a 2000 ft^2 ranch home built in accordance with the 2000 IECC is provided below.

- Location of home (Des Moines, IA)
- Utility rates ($0.10/kWh for electricity, $1.00/Therm for fuel)
- Building use (residential, office, lodging)
- HVAC system (DX cooling with gas furnace, air source heat pump)
- Floor area (2000 ft^2)

- Floor-to-floor height (8 ft)
- Number of stories (1)
- Wall construction (2 x 6 frame)
- User-supplied *R*-value for the walls (R-18)
- Roof construction (attic)
- User-supplied *R*-value for the roof (R-38)
- Floor type (basement)
- Window type (4060 low-e al/b)
- User supplied *U*-factor for the windows (U = 0.35)
- Glazing to wall ratio (0.10)
- Air infiltration rate (0.4 air changes per hour (ACH))
- Duct leakage to indoors (0%)

8.4 Energy 10 Program Outputs

After entering the Program Inputs into Energy 10 for the home of interest, various outputs are provided to the user. Some of the outputs for the 2000 ft^2 ranch home are listed below (cited parenthetically).

- The total surface area of the home (5517.9 ft^2)
- The total volume of the home (16000 ft^3)
- Total conduction, UA, was 392.5 Btu/h-°F
- Total gross wall area (1518 ft^2)
- Total gross roof area (2000 ft^2)
- Total gross window area (240 ft^2)
- Heating thermostat temperature (70°F)
- Cooling thermostat temperature (78°F)

8.5 Operating Cost Savings

The annual energy consumption and operating costs to heat and cool three different categories of homes, with varying energy efficiencies, were determined using Energy 10. By specifying different materials and construction techniques into Energy 10, the three categories of homes represent either 2000 IECC standards, current practice standards or low efficiency standards. The latter case, low efficiency standards, is a home that would not have emphasized energy conservation during initial construction. Operating costs for the three home categories were then used to determine the energy cost savings (i.e., gas for heating and electricity for cooling) to operate a 2000 IECC home compared to either a current practice home or a low efficiency home.

The three categories of home construction also correspond to the categories used elsewhere in this report to determine material, labor, and equipment costs to build homes to different efficiency levels. Specifically, cost differences to upgrade homes from either current practice or

low efficiency to 2000 IECC standards were determined earlier for a range of home styles and sizes.

The operating cost savings for the three home categories, namely 2000 IECC, current practice and low efficiency, were determined by Energy 10 for three home styles (ranch, 2-story and split-level) for three home sizes, namely, 1000, 2000 and 3000 ft^2. The wall type for each home style assumes 2 × 6 boards, and the distance between floor and ceiling is 8 ft. Also, all windows were assumed to be 4060 low emissivity with an aluminum base and the assumed door area was 45.5 ft^2. As noted in Section 7, each of the home categories represent different levels of energy efficiency, and therefore different ceiling/wall *R*-values and window *U*-values were selected for each home category as shown in Table 8.1 The infiltration values for both windows and doors, and leakage is shown in Table 8.2 for the three home sizes for each home category.

Results of the operating cost analysis for the three home categories are tabulated in Tables 8.3-8.5. The natural gas and electricity rates selected for the operating cost analysis are $1/therm and 10¢/kW·h, respectively. For example, Table 8.3 shows that annual operating costs for heating a 2000 ft^2 ranch home varies from $1,062 for the low efficiency home to $720 for the 2000 IECC home. The annual operating costs for cooling the ranch home varies from $286 for the low efficiency home to $258 for the 2000 IECC home; clearly cooling costs are do not change significantly with building practice. Also noteworthy is that if ducts are improved for the 2-story and split-level homes, the annual heating costs reduce considerably. Both annual operating costs per floor area and total annual operating costs for other home styles, namely 2-story and split-level area also shown in Tables 8.3 and 8.4 for all three home categories. The total operating costs are summarized in Table 8.5 and Figs. 8.1-8.3 for the ranch, 2-story and split-level homes, respectively.

8.6 Payback Periods for Implementing 2000 IECC

The cost differences to build houses to 2000 IECC standards can also be used to determine a simple payback period for constructing homes to 2000 IECC standards. Specifically, these cost differences can be divided by annual energy savings for a 2000 IECCC home to determine the simple payback period (i.e., years) to construct a new home to 2000 IECC standards.

Table 8.6 summarizes the annual operating and material cost differences to upgrade low efficiency and current practice homes to 2000 IECC standards. The payback period for building a 2000 ft^2 ranch home to 2000 IECC standards is 4.5 years for a low efficiency home and 4.9 years for a current practices home. For the same 2000 ft^2 size, the payback period for a 2-story home built to 2000 IECC standards compared to low efficiency and current practice is 4.3 years and 5.5 years, respectively. For a split-level home, the payback period for building a home to 2000 IECC standards is 4.5 years for low efficiency standards and 5.4 years for current practices.

Table 8.1. Summary of building dimensions and values for the building practices for each home style.

Style	Building Practice	Gross Wall Area (ft^2)	Window Area (ft^2)	Window/ Wall Ratio	Glazing/ Wall Ratio	Glazing U-factor, $Btu/(h \cdot ft^2 \cdot °F)$	Wall Insulation R-value, $(h \cdot ft^2 \cdot °F)/Btu$	Ceiling Insulation R-value, $(h \cdot ft^2 \cdot °F)/Btu$
Ranch	2000 IECC	1518	240	0.158	0.1	0.35	18	38
	Current Practice	1518	240	0.158	0.1	0.49	13	30
	Low Efficiency	1518	240	0.158	0.1	0.75	11	19
2-Story	2000 IECC	2024	288	0.142	0.1	0.35	18	38
	Current Practice	2024	288	0.142	0.1	0.49	13	30
	Low Efficiency	2024	288	0.142	0.1	0.75	11	19
Split-Level	2000 IECC	2066	384	0.186	0.1	0.35	18	38
	Current Practice	2066	384	0.186	0.1	0.49	13	30
	Low Efficiency	2066	384	0.186	0.1	0.75	11	19

Table 8.2. Summary of infiltration and leakage for the building practices for each home style.

Style	Building Practice	Window Infiltration Rate, cfm/ft^2	Window Infiltration, cfm	Door Infiltration Rate, $cfmft^2$	Door Infiltration, cfm	Total Infiltration, cfm	ACH	Indoor Duct Leakage
Ranch	2000 IECC	0.3	72	0.5	22.75	94.75	0.36	0%
	Current Practice	0.4	96	0.6	27.3	123.3	0.46	2%
	Low Efficiency	0.5	120	0.7	31.85	151.85	0.57	2%
2-Story	2000 IECC	0.3	86.4	0.5	22.75	109.15	0.41	0%
	Current Practice	0.4	115.2	0.6	27.3	142.5	0.53	2%
	Low Efficiency	0.5	144	0.7	31.85	175.85	0.66	2%
Split-Level	2000 IECC	0.3	115.2	0.5	22.75	137.95	0.52	0%
	Current Practice	0.4	153.6	0.6	27.3	180.9	0.68	2%
	Low Efficiency	0.5	192	0.7	31.85	223.85	0.84	2%

Table 8.3. Summary of annual heating energy loads and costs for each building practice and home style.

Style	Size (ft^2)	Building Practice	Annual Heating Load (kBtu)	Annual Heating Costs	*UA* (Btu/h·°F)	Annual Heating Cost With Duct Improvements	Annual Heating Cost Per Area ($/$ft^2$)
Ranch	1000	Low Efficiency	60,717	$607.17	354.6	$607.17	$0.61
		Current Practice	52,089	$520.89	322.9	$520.89	$0.52
		2000 IECC	41,327	$413.27	278.4	$413.27	$0.41
	2000	Low Efficiency	106,175	$1,061.75	606.5	$1,061.75	$0.53
		Current Practice	90,354	$903.54	550.6	$903.54	$0.45
		2000 IECC	71,974	$719.74	479.3	$719.74	$0.36
	3000	Low Efficiency	150,411	$1,504.11	828.0	$1,504.11	$0.50
		Current Practice	127,478	$1,274.78	749.0	$1,274.78	$0.42
		2000 IECC	102,683	$1,026.83	658.8	$1,026.83	$0.34
2-Story	1000	Low Efficiency	54,234	$542.34	340.7	$488.11	$0.49
		Current Practice	46,545	$465.45	314.3	$418.91	$0.42
		2000 IECC	34,534	$345.34	260.6	$310.81	$0.31
	2000	Low Efficiency	87,509	$875.09	530.3	$787.58	$0.39
		Current Practice	73,941	$739.41	487.3	$665.47	$0.33
		2000 IECC	54,705	$547.05	407.2	$492.35	$0.25
	3000	Low Efficiency	120,625	$1,206.25	715.4	$1,085.63	$0.36
		Current Practice	101,542	$1,015.42	658.0	$913.88	$0.30
		2000 IECC	75,509	$755.09	554.9	$679.58	$0.23
Split-Level	1000	Low Efficiency	74,858	$748.58	430.8	$673.72	$0.67
		Current Practice	66,641	$666.41	401.4	$599.77	$0.60
		2000 IECC	53,253	$532.53	340.8	$479.28	$0.48
	2000	Low Efficiency	119,826	$1,198.26	670.8	$1,078.43	$0.54
		Current Practice	105,195	$1,051.95	622.1	$946.76	$0.47
		2000 IECC	83,287	$832.87	528.5	$749.58	$0.37
	3000	Low Efficiency	157,880	$1,578.80	809.9	$1,420.92	$0.47
		Current Practice	136,713	$1,367.13	742.1	$1,230.42	$0.41
		2000 IECC	109,016	$1,090.16	634.4	$981.14	$0.33

Table 8.4. Summary of annual cooling energy loads and costs for each building practice and home style.

Style	Size (ft^2)	Building Practice	Annual Cooling Load (kW·h)	Annual Cooling Costs	Annual Cooling Cost With Duct Improvements	Annual Cooling Cost Per Area ($/$ft^2$)
Ranch	1000	Low Efficiency	1,569	$156.90	$141.21	$0.14
		Current Practice	1,458	$145.80	$131.22	$0.13
		2000 IECC	1,404	$140.40	$126.36	$0.13
	2000	Low Efficiency	2,864	$286.40	$257.76	$0.13
		Current Practice	2,660	$266.00	$239.40	$0.12
		2000 IECC	2,577	$257.70	$231.93	$0.12
	3000	Low Efficiency	3,749	$374.90	$337.41	$0.11
		Current Practice	3,450	$345.00	$310.50	$0.10
		2000 IECC	3,322	$332.20	$298.98	$0.10
2-Story	1000	Low Efficiency	2,010	$201.00	$180.90	$0.18
		Current Practice	1,939	$193.90	$174.51	$0.17
		2000 IECC	1,918	$191.80	$172.62	$0.17
	2000	Low Efficiency	3,298	$329.80	$296.82	$0.15
		Current Practice	3,178	$317.80	$286.02	$0.14
		2000 IECC	3,158	$315.80	$284.22	$0.14
	3000	Low Efficiency	4,556	$455.60	$410.04	$0.14
		Current Practice	4,386	$438.60	$394.74	$0.13
		2000 IECC	4,364	$436.40	$392.76	$0.13
Split-Level	1000	Low Efficiency	2,412	$241.20	$217.08	$0.22
		Current Practice	2,320	$232.00	$208.80	$0.21
		2000 IECC	2,287	$228.70	$205.83	$0.21
	2000	Low Efficiency	4,070	$407.00	$366.30	$0.18
		Current Practice	3,910	$391.00	$351.90	$0.18
		2000 IECC	3,873	$387.30	$348.57	$0.17
	3000	Low Efficiency	4,777	$477.70	$429.93	$0.14
		Current Practice	4,546	$454.60	$409.14	$0.14
		2000 IECC	4,473	$447.30	$402.57	$0.13

Table 8.5. Total operating costs for each building practice and home style.

Style	Size (ft^2)	Building Practice	Total Annual Operating Costs
Ranch	1000	Low Efficiency	$748
		Current Practice	$652
		2000 IECC	$540
	2000	Low Efficiency	$1,320
		Current Practice	$1,143
		2000 IECC	$952
	3000	Low Efficiency	$1,842
		Current Practice	$1,585
		2000 IECC	$1,326
2-Story	1000	Low Efficiency	$669
		Current Practice	$593
		2000 IECC	$483
	2000	Low Efficiency	$1,084
		Current Practice	$951
		2000 IECC	$777
	3000	Low Efficiency	$1,496
		Current Practice	$1,309
		2000 IECC	$1,072
Split-Level	1000	Low Efficiency	$891
		Current Practice	$809
		2000 IECC	$685
	2000	Low Efficiency	$1,445
		Current Practice	$1,299
		2000 IECC	$1,098
	3000	Low Efficiency	$1,851
		Current Practice	$1,640
		2000 IECC	$1,384

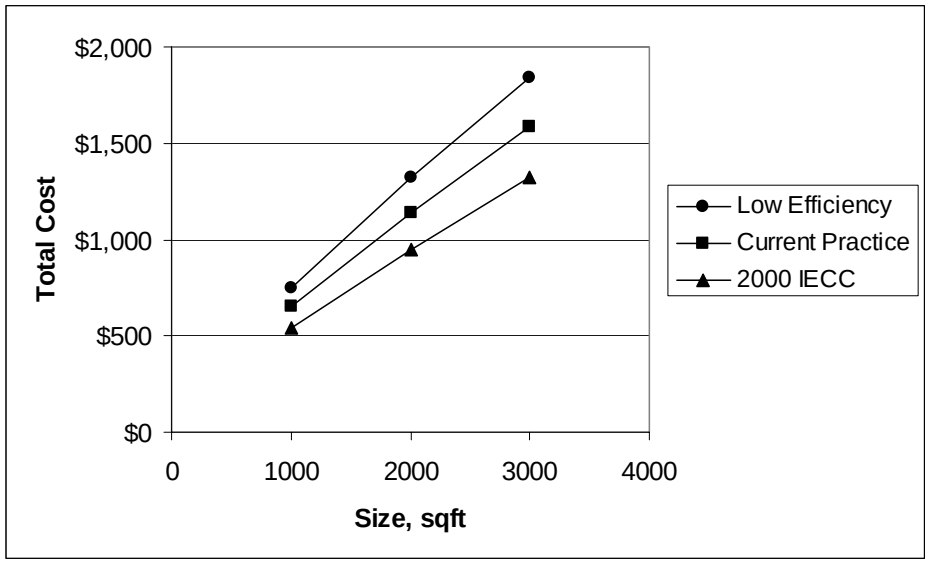

Figure 8.1. Total annual operating cost versus total floor area for a ranch-style home.

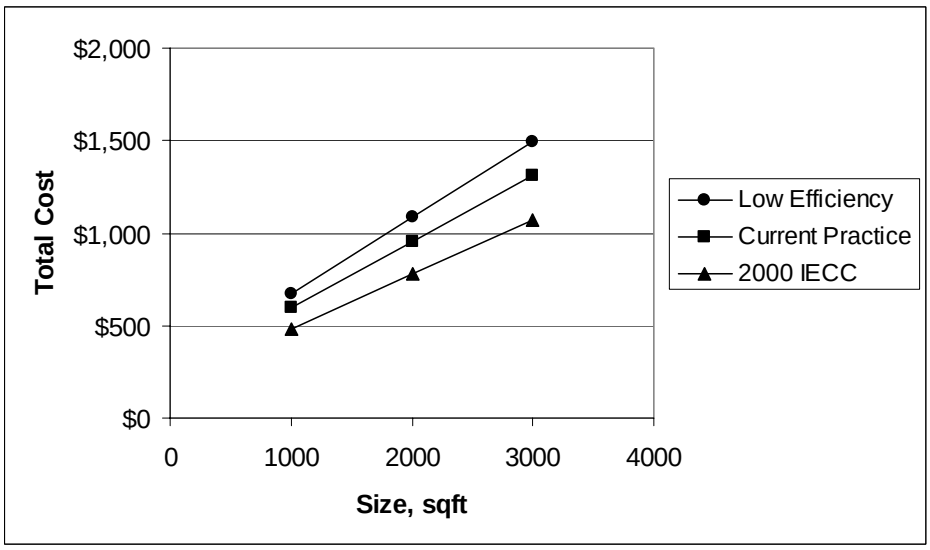

Figure 8.2. Total annual operating cost versus total floor area for a 2-story home.

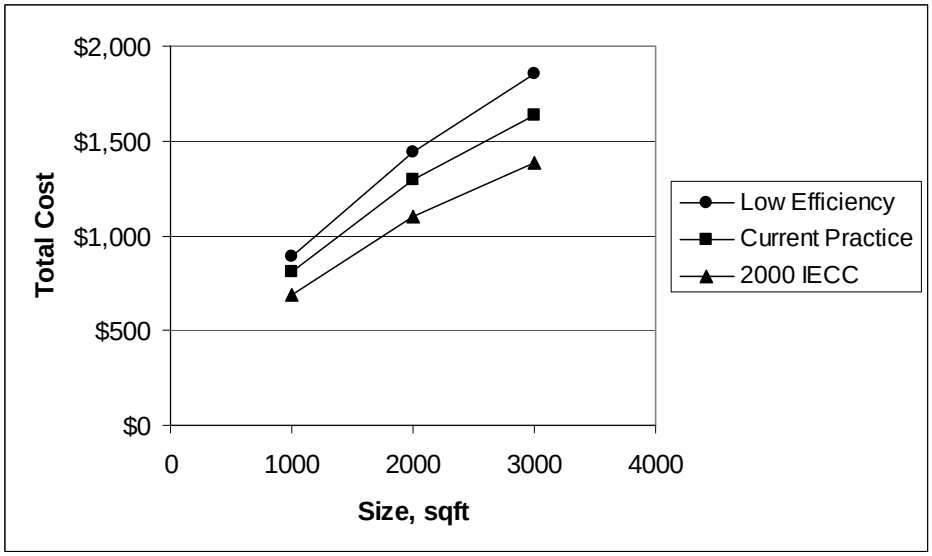

Figure 8.3. Total annual operating cost versus total floor area for a split-level home.

Table 8.6. Operating and material cost differences with payback period for each building practice and home style.

Style	Size (ft^2)	Building Practice	Annual Operating Cost Difference	Material Costs Difference	Simple Payback Period
Ranch	1000	Low Efficiency to 2000 IECC	$208	$974	4.7 years
		Current Practice to 2000 IECC	$112	$616	5.5 years
	2000	Low Efficiency to 2000 IECC	$368	$1,641	4.5 years
		Current Practice to 2000 IECC	$191	$935	4.9 years
	3000	Low Efficiency to 2000 IECC	$516	$2,292	4.4 years
		Current Practice to 2000 IECC	$259	$1,240	4.8 years
2-Story	1000	Low Efficiency to 2000 IECC	$186	$901	4.8 years
		Current Practice to 2000 IECC	$110	$706	6.4 years
	2000	Low Efficiency to 2000 IECC	$307	$1,331	4.3 years
		Current Practice to 2000 IECC	$174	$956	5.5 years
	3000	Low Efficiency to 2000 IECC	$424	$1,731	4.1 years
		Current Practice to 2000 IECC	$237	$1,179	5.0 years
Split-Level	1000	Low Efficiency to 2000 IECC	$206	$1,030	5.0 years
		Current Practice to 2000 IECC	$124	$774	6.2 years
	2000	Low Efficiency to 2000 IECC	$347	$1,573	4.5 years
		Current Practice to 2000 IECC	$201	$1,077	5.4 years
	3000	Low Efficiency to 2000 IECC	$467	$2,082	4.5 years
		Current Practice to 2000 IECC	$256	$1,351	5.3 years

9 Conclusions

The objective of this project was to compare energy consumption and incremental building costs when single-family residential homes are built and operated according to different codes, namely the 2000 International Energy Conservation Code and the 1992 Model Energy Code or lesser. The lack of quantitative information, such as energy savings and incremental building costs, has made it difficult to mandate that Iowa builders follow these codes. This report has attempted to answer questions of how much energy savings can be achieved by implementing energy savings steps described in 2000 IECC.

A total of 30 homes were selected for this study with 10 homes located in each of the three weather regions of Iowa, i.e., northern, central and southern regions. The study restricted the energy used by each home to natural gas for heating and electricity for cooling. The three basic home styles included in the study were ranch, 2-story and split-level/1-1/2 story homes. Raw data was collected for each home by performing an in-home energy audit and by collecting utility data for natural gas and electricity over a two-year period. The raw data was normalized using the heating degree day data for each weather region.

A linear relationship was determined for the natural gas consumption for one year as a function of the heating degree day per day. The slope of the line is equivalent to the thermal conductance, *UA*, which represents the energy efficiency of the building envelope. Thermal conductance trends were demonstrated for each home style versus parameters such as total floor area, wall area (above ground), window area and ceiling area. The thermal conductance trends indicated that heat loss was primarily a function of the geometry of the homes. Using multiple regression, a predicted value of *UA* was determined from which the percent error was extracted, providing 80% confidence in the experimental *UA* values determined from the raw data.

The experimental *UA* values were compared to thermal conductance values for the prescriptive method provided in the 2000 IECC and for values calculated assuming construction according to 2000 IECC. The thermal conductance values using the 2000 IECC method were based on *R*- and *U*-values for basement, walls, windows and ceiling dimensions. It was also necessary to modify the experimental *UA* values with the furnace efficiency. The thermal conductance values between the 2000 IECC method and the modified furnace *UA* values were compared in order to identify which of the 30 homes met the 2000 IECC standards. It was found that 16 of the 30 homes satisfied the 2000 IECC criteria. The results indicated that homes that met the 2000 IECC had lower *UA* values and lower natural gas costs.

The additional cost of building homes to 2000 IECC standards compared to more conventional building practices (i.e., either current practices or low efficiency practices) was determined for a range of floor areas and for the three main home styles, namely, ranch, 2-story and split-level. The additional costs were for materials, labor and equipment to install extra insulation in walls, ceilings and ducting. Costs were also considered for sealing ducts by using tape and for installing windows with higher *U*-values as specified in 2000 IECC.

The reduced heating and cooling energy consumption for 2000 IECC homes compared to homes built to lesser standards was determined for a range of home styles and sizes. The annual energy

consumption along with annual heating and cooling loads were determined by using Energy 10. The models of the 2000 IECC, current practice and low efficiency homes were distinguished in each Energy 10 analysis by using different wall *R*-values, ceiling *R*-values and window *U*-values. The cost savings of operating 2000 IECC homes was found by taking the various differences in annual operating costs. By dividing the additional material costs to build homes to 2000 IECC standards by the operating cost savings, then the simple payback period was determined. These payback periods varied from a low of 4.1 years to a high of 6.4 years.

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Appendices

A. Summary of schematics, specifications and calculations for each home.
B. Raw energy consumption data for each home.
C. Natural gas and electricity usage for each home.
D. Natural gas versus HDD/day for each home (one-year period).
E. Selection of Homes, letters and forms.

Notation:

Northern Region is denoted by A
Central Region is denoted by B
Southern Region is denoted by C

Numbers following the region letter range from 1 to 10, denoting each house with a region.

Appendix A

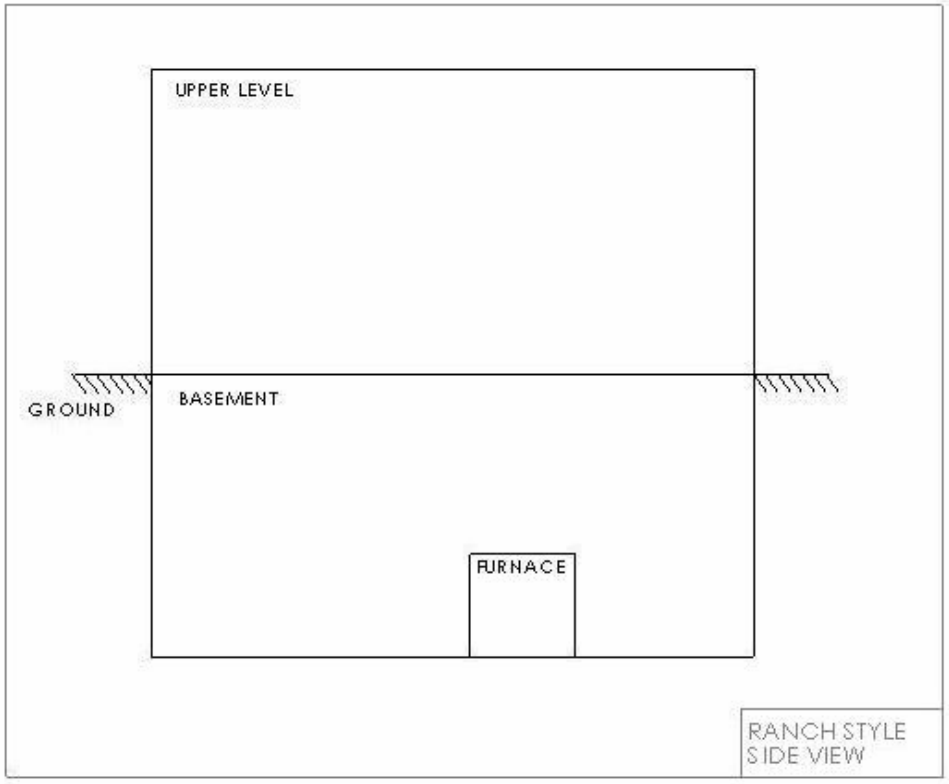
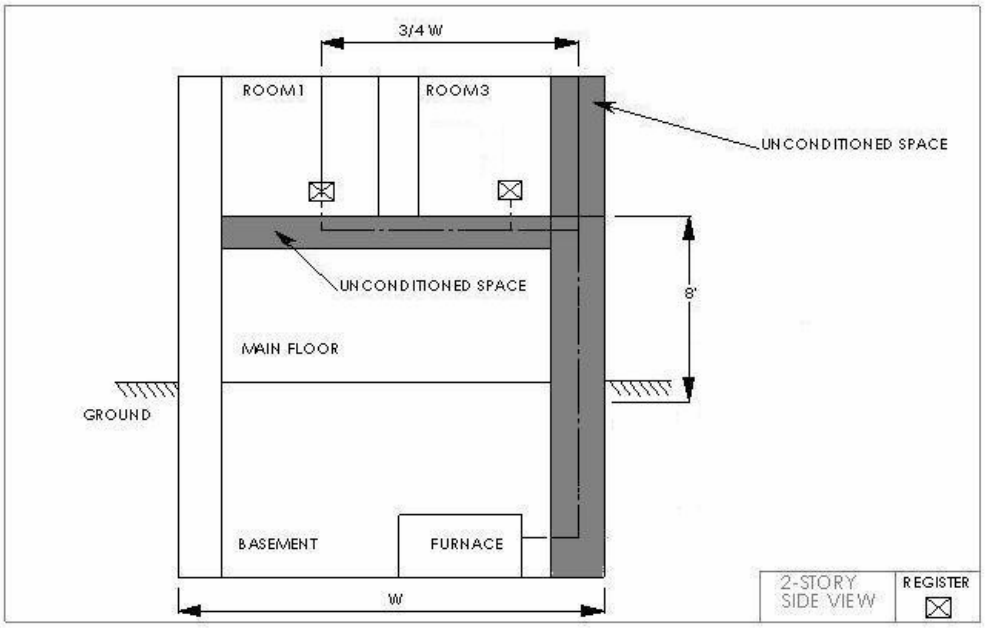
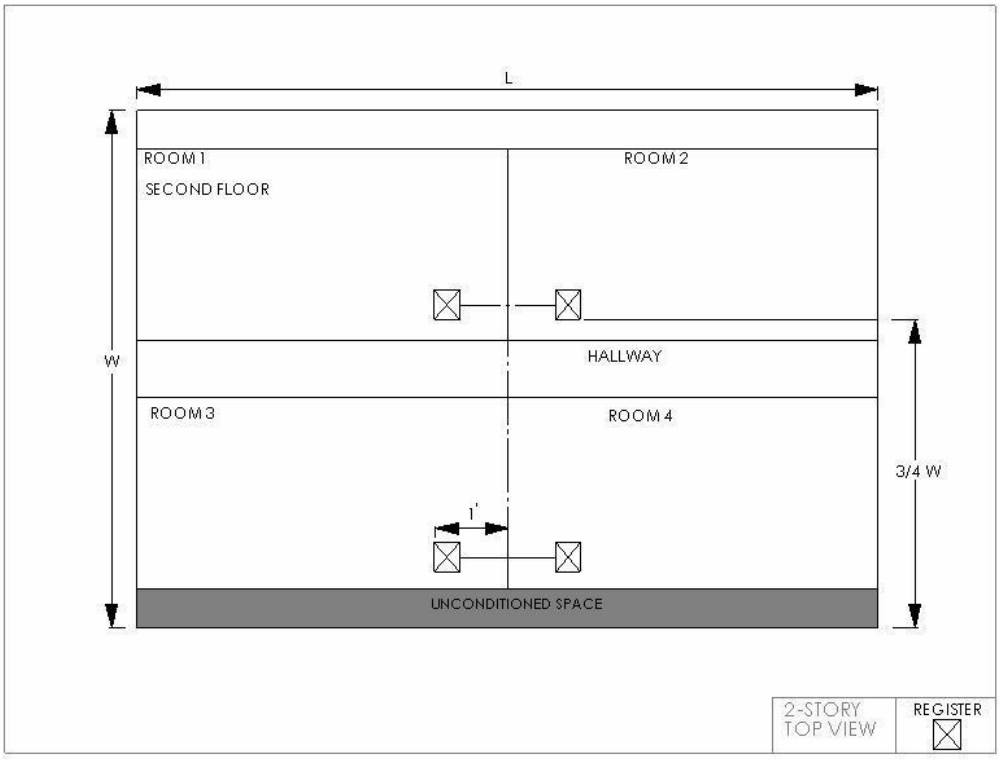


Figure A.1. Schematic of the side view of a ranch-style home.

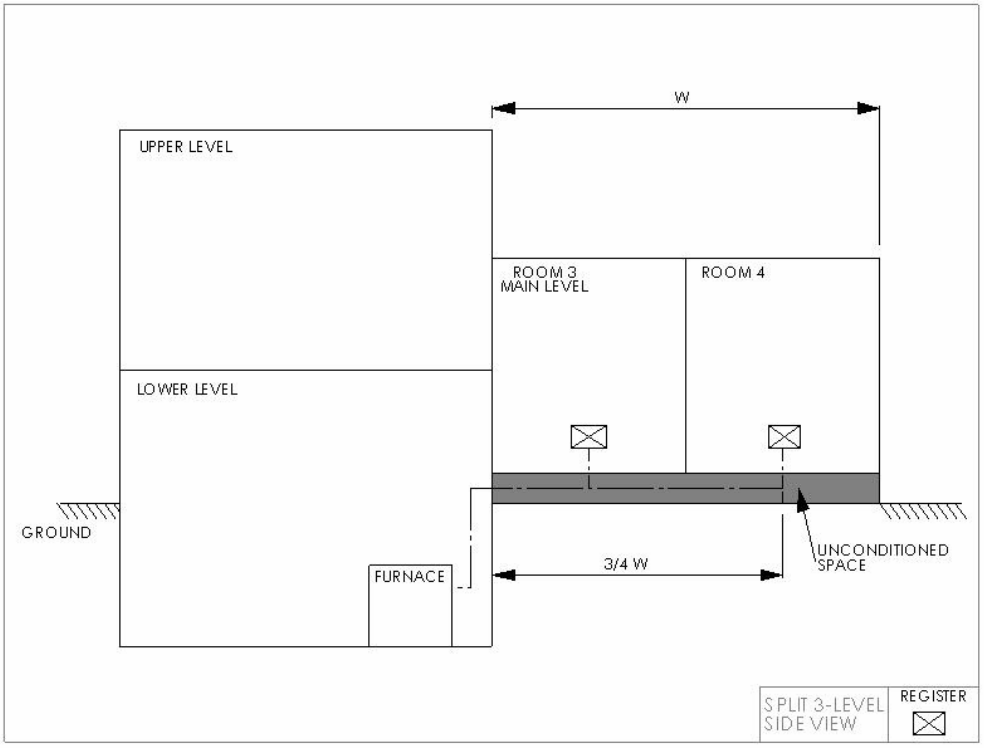


(a)

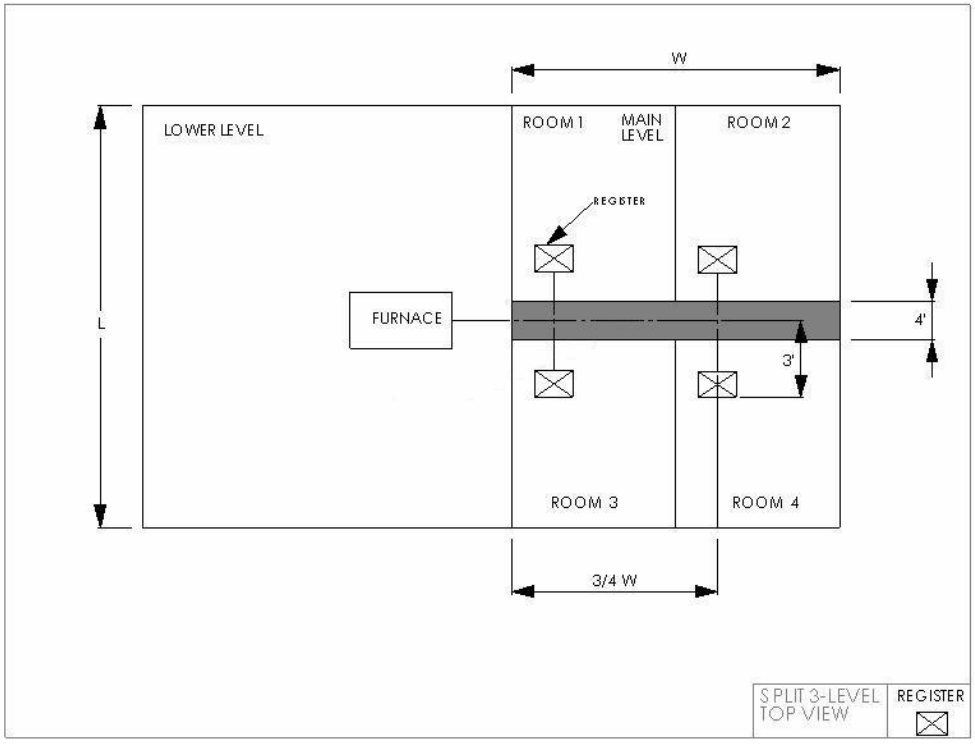


(b)

Figure A.2. Schematic of a 2-story home for the (a) side view and (b) top view.



(a)



(b)

Figure A.3. Schematic of a split-level (3 levels) home for the (a) side view and (b) top view.

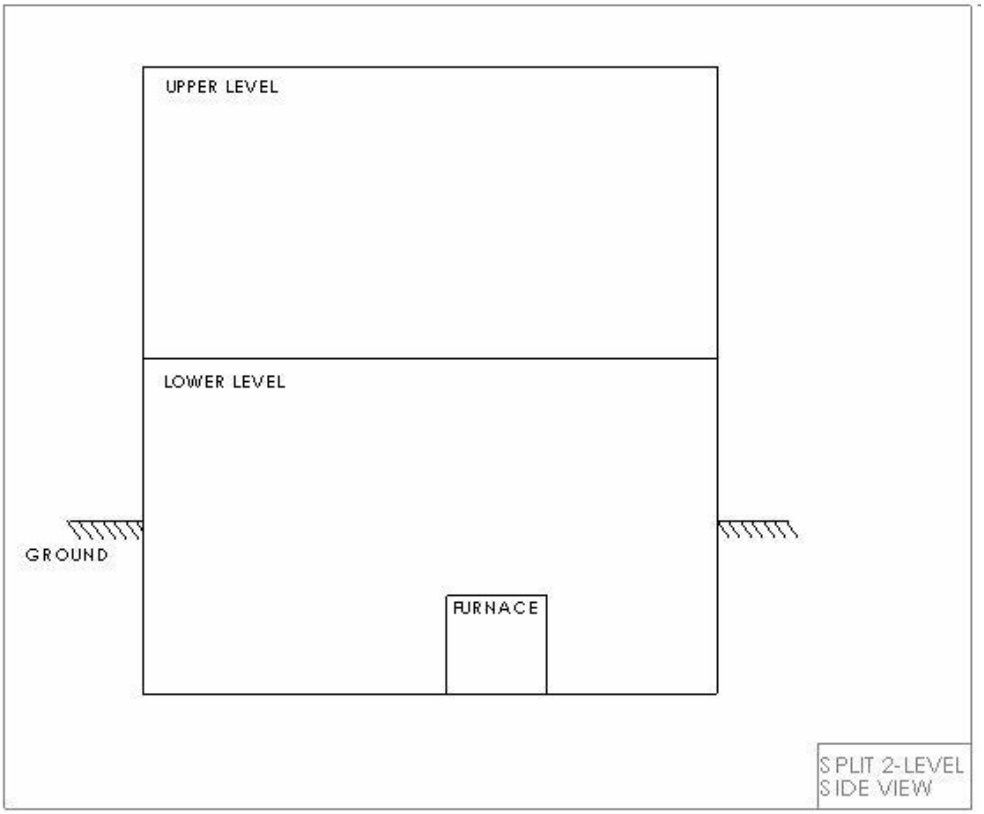


Figure A.4. Schematic of the side view of a split 2-level home.

Table A.1. Home characteristics and settings.

Home Number	Style	Age, Years	People	Thermostat Day	Thermostat Night	Fire place	Heated Basement	Finished basement	Supply Duct Basement
A-1	Ranch	20	2	73	73	Yes	Yes	Yes	Yes
A-2	2-Story	4	5	72	68	Yes	Yes	No	No
A-3	Ranch	2	4	71	68	Yes	Yes	Yes	Yes
A-4	Ranch	7	2	72	65	Yes	Yes	Yes	Yes
A-5	Split-Level	9	2	68	65	Yes	Yes	Yes	Yes
A-6	Ranch	3	2	68	60	No	Yes	Yes	Yes
A-7	Ranch	7	2	69	62	Yes	Yes	Yes	Yes
A-8	Split-Level	13	5	70	70	Yes	Yes	Yes	Yes
A-9	Ranch	7	2	68	68	No	Yes	Yes	No
A-10	1-1/2 Story	9	4	68.5	65	No	Yes	Yes	No
B-1	Ranch	2	2	63	60	Yes	Yes	No	No
B-2	1-1/2 Story	2	3	62	65	Yes	Yes	Yes	Yes
B-3	Ranch	2	1	68	68	Yes	Yes	Yes	Yes
B-4	2-Story	12	5	73	73	No	Yes	Yes	No
B-5	2-Story	2	5	68	68	No	Yes	Yes	No
B-6	Ranch	9	4	72	72	Yes	Yes	Yes	Yes
B-7	Split-Level	8	2	70	70	No	Yes	Yes	Yes
B-8	Ranch	6	2	72	70	Yes	Yes	Yes	No
B-9	2-Story	6.5	6	68	69	Yes	Yes	Yes	Yes
B-10	1-1/2 Story	3	4	66	66	Yes	Yes	No	No
C-1	2-Story	2	5	68	68	Yes	Yes	Yes	Yes
C-2	Ranch	2.5	3	70	73	Yes	Yes	Yes	No
C-3	Ranch	11	2	68	68	Yes	Yes	Yes	Yes
C-4	Ranch	4.5	2.5	68	66	Yes	Yes	Yes	Yes
C-5	2-Story	10	2	72	66	Yes	Yes	Yes	Yes
C-6	2-Story	7	2	67	63	Yes	Yes	Yes	Yes
C-7	Ranch	2	4	70	70	Yes	Yes	No	No
C-8	Ranch	12	2	70	70	Yes	Yes	Yes	Yes
C-9	Ranch	2	3	70	67	No	Yes	Yes	No
C-10	2-Story	12	2	67	67	Yes	Yes	Yes	Yes

Table A.2. Home furnace and air-conditioning manufacturers.

Home Number	Style	Furnace/Boiler Information	A/C Information
A-1	Ranch	Rheem High Efficiency (1983)	Rheem High Efficiency (RACB-036JAQ)
A-2	2-Story	Lennox Elite Series (Model C23-51-1) (92.5 AFUE)	Lennox Value Series
A-3	Ranch	Conquest 90 (92 AFUE)	Heat Controller, Inc. Comfort Air (10SEER)
A-4	Ranch	Carrier Weathermaker 9200 (95.5 AFUE)	Carrier Tech 2000 SS Silencer System
A-5	Split-Level	Carrier Weathermaker 9200 (95.5 AFUE)	Carrier Tech 2000 High Efficiency
A-6	Ranch	Tempstar (92 AFUE)	Tempstar Villager Series
A-7	Ranch	Ultra SX90 (90 AFUE)	Armstrong Concept 12 High Efficiency (13 SEER)
A-8	Split-Level	Trane 90XL (~1 year old) (92 AFUE)	Rheem High Efficiency
A-9	Ranch	Weather King 90 Plus	Weather King 12 SEER
A-10	1-1/2 Story	Weather King 90 Plus	Weather King Select 10 High Efficiency
B-1	Ranch	Trane XE 90 (90 AFUE)	Trane XE 1200 "13 SEER"
B-2	1-1/2 Story	Trane XE 90 (90 AFUE)	Trane XE 1200 High Efficiency
B-3	Ranch	American Standard Freedom 90 (90 AFUE)	American Standard Allegiance 12 2000
B-4	2-Story	Comfortmaker Super High Efficiency (90 AFUE)	Comfortmaker
B-5	2-Story	Tempstar DC 90 (90 AFUE)	Tempstar 10
B-6	Ranch	Lennox Pulse 21 (93.2 AFUE)	Lennox
B-7	Split-Level	Lennox (Model 26-26-1)	Lennox
B-8	Ranch	Lennox Elite Series (92.5 AFUE)	Lennox Elite series
B-9	2-Story	Heil DC 90 ultra high efficiency (90 AFUE)	Heil 5000 High Efficiency
B-10	1-1/2 Story	Trane XE 90 (90 AFUE)	Trane High Efficiency XE 1000
C-1	2-Story	Ruud Achiever 90 Plus (94 AFUE)	Ruud Achiever High Efficiency
C-2	Ranch	Heil DC 90 ultra high efficiency (90 AFUE)	Heil Max Performance 14
C-3	Ranch	Lennox Pulse 21 (93.2 AFUE)	Lennox (Model HS24-311-1P)
C-4	Ranch	Tempstar DC90 Ultra High Efficiency (90 AFUE)	Tempstar 9000 Super High Efficiency
C-5	2-Story	Amana Air Command High Efficiency 90 (92 AFUE)	Amana Super Efficiency
C-6	2-Story	Lennox Elite Series	Lennox
C-7	Ranch	Ruud Achiever 90 Plus (94 AFUE)	RUUD Achiever High Efficiency
C-8	Ranch	Lennox Pulse	Lennox (Model HS24-261-1P)
C-9	Ranch	Lennox Pulse 21 (93.2 AFUE)	Lennox Elite Series
C-10	2-Story	Heil	Heil High Efficiency

Table A.3. Home window, insulation and exterior characteristics.

Home Number	Style	Window Panes	Attic Insulation	Walls	Loc of Garage	House close by
A-1	Ranch	Single	6 inches blown cellulous with 7 inches fiberglass.	4 inches with 4 inch insulation with a 1 inch insulation board with foil. Rib joist on north side is insulated.	West	Yes
A-2	2-Story	Double	12 inches		North	Yes
A-3	Ranch	Double	16 inches		East	Yes
A-4	Ranch	Double	14 inches		West	No
A-5	Split-Level	Double			NW	No
A-6	Ranch	Double	R-40	6 inch	East	Yes
A-7	Ranch	Double	14 inches	6 inches with 6 inch insulation.	South	No
A-8	Split-Level	Double	18 inches	6 inches with 6 inch insulation.	West	No
A-9	Ranch	Double	12 inches	4 inch (R-13), 3/4 inch board (R-6), house wrap (R-2)	North	No
A-10	1-1/2 Story	Double		6 inch walls	NW	No
B-1	Ranch	Double			South	No
B-2	1-1/2 Story	Double			South	No
B-3	Ranch	Double	R-45	R-27	South	No
B-4	2-Story				South	Yes
B-5	2-Story	Double	12 inches		West	Yes
B-6	Ranch	Double	19 inches	6 inches	NE	No
B-7	Split-Level	Double	At least 10 inches		North	Yes
B-8	Ranch	Double	18 inches		South	No
B-9	2-Story	Double		6 inch	West	No
B-10	1-1/2 Story	Double	R- 40 or R-44	6 inch with R-19	SW	Yes
C-1	2-Story	Double	R-38 to R-44	6 inch with R-19	North	No
C-2	Ranch	Double	12 inches	6 inches insulation	NE	No
C-3	Ranch	Double	12 inches	4 inches insulation	North	No
C-4	Ranch	Triple			South	Yes
C-5	2-Story	Double			North	No
C-6	2-Story	Double	12 inches	6 inch walls	North	No
C-7	Ranch	Double	R-46 (16 inches)	4 inch with R-13 and insulating board.	West	No
C-8	Ranch	Double	12 inches		North	No
C-9	Ranch	Double	R-40	6 inch with R-19	North	No
C-10	2-Story	Double			West	No

Table A.4. Home builder and additional comments.

Home Number	Style	Home Builder	Comments	Additional Comments
A-1	Ranch	Unknown		
A-2	2-Story	Star Homes, Inc.	Duct seams were taped, tape was in good condition.	Garage under second floor
A-3	Ranch	Self		
A-4	Ranch	private contractor		Thermostat set to 45 °F during Dec.-Mar.
A-5	Split-Level	Leisinger Construction		
A-6	Ranch	Unknown		
A-7	Ranch	Hartzel and Rosenberg Const.	Air heat pump (13 SEER) and is only used as an A/C.	
A-8	Split-Level	Tony Dudley Construction	Well insulated and duct seams were taped. The tape was in good condition.	
A-9	Ranch	Ruben Schwartz & Sons Const.		1992 MEC built
A-10	1-1/2 Story	Jack Reuter Const.		Garage not attached
B-1	Ranch	Dricoll Construction	County adopted the 2000 IECC	Trees all around house.
B-2	1-1/2 Story	Todd Whitters Construction L L C	County adopted the 2000 IECC.	
B-3	Ranch	Schrock Steel Homes Inc	County adopted the 2000 IECC	5-Star rating.
B-4	2-Story	Unknown		
B-5	2-Story	Hunziker Construction, Inc.	Some builders in Ames use the 2000 IECC	
B-6	Ranch	Lyle Michael Construction		
B-7	Split-Level	Jones Homes		Garage under main floor
B-8	Ranch	Quality Custom Home Builders Inc	Energy star rated by MidAmerican Energy.	Garage under main floor
B-9	2-Story	Gulling Homes		1992 MEC built
B-10	1-1/2 Story	Chamberlain Brothers Lumber & Construction		
C-1	2-Story	Hoble Construction		
C-2	Ranch	Miller Construction Co.		
C-3	Ranch	Self		
C-4	Ranch	Loran Roling Const.		
C-5	2-Story	McCoy/Winkler		
C-6	2-Story	H & H Home Builders of North Liberty	Some tape on duct seams, but not on all seams.	1992 MEC built
C-7	Ranch	Freyenberger Construction		
C-8	Ranch	Unknown		
C-9	Ranch	Wick Home Statler Construction Inc		
C-10	2-Story	Mike Sereg Builders Inc		

Table A.5. Summary of house style, residents and dimensions.

Home Number	Age (years)	Style	People	First Floor Area (ft^2)	Second Floor Area (ft^2)	Total Floor Area (above ground) (ft^2)	Basement or Lower Level Area (ft^2)	Basement or Lower Level Wall Area (ft^2)	Ceiling Area (ft^2)	Wall Area (above ground) (ft^2)	Window Area (ft^2)
A-1	20	Ranch	2	1512	0	1512	1512	1320	1512	1344	146
A-3	2	Ranch	4	1850	0	1850	1600	1357	1850	1656	321
A-4	7	Ranch	2	1800	0	1800	1800	1440	1800	1620	186
A-6	3	Ranch	2	1800	0	1800	1800	1440	1800	1800	114
A-7	7	Ranch	2	2152	0	2152	2152	1575	2152	1378	279
A-9	7	Ranch	2	1520	0	1520	1520	1324	1520	1322	231
B-1	2	Ranch	2	2360	0	2360	3160	1907	2360	1750	232
B-3	2	Ranch	1	1675	0	1675	1649	1378	1675	1494	273
B-6	9	Ranch	4	2072	0	2072	1760	1425	2072	1632	156
B-8	6	Ranch	2	2180	0	2180	1604	1359	2180	1512	362
C-2	2.5	Ranch	3	1972	0	1972	1972	1507	1972	1748	181
C-3	11	Ranch	2	1400	0	1400	1400	1271	1400	1248	110
C-4	4.5	Ranch	2.5	1725	0	1725	1725	1410	1725	1400	207
C-7	2	Ranch	4	1536	0	1536	1536	1330	1536	1280	135
C-8	12	Ranch	2	1400	0	1400	1400	1271	1400	1248	144
C-9	2	Ranch	3	1624	0	1624	1624	1368	1624	1331	268
A-2	4	2-Story	5	750	1450	2200	750	877	1450	2253	183
B-4	12	2-Story	5	1068	810	1878	650	816	1068	1962	265
B-5	2	2-Story	5	917	858	1775	823	918	917	1936	209
B-9	6.5	2-Story	6	1150	1150	2300	700	847	1150	2272	280
C-1	2	2-Story	5	1568	1280	2848	1568	1267	1568	2496	299
C-5	10	2-Story	2	1113	1280	2393	1113	1068	1280	2221	188
C-6	7	2-Story	2	753	1000	1753	753	878	1000	1922	196
C-10	12	2-Story	2	1170	871	2041	1040	1032	1170	2349	233
A-5	9	Split-Level	2	728	664	1392	728	863	1392	1754	185
A-8	13	Split-Level	5	1300	0	1300	1248	1131	1300	1216	183
A-10	9	1-1/2 Story	4	1280	620	1900	1280	1145	1280	1974	289
B-2	2	1-1/2 Story	3	1266	1040	2306	1037	1031	1266	2455	196
B-7	8	Split-Level	2	1025	0	1025	525	733	1025	1056	142
B-10	3	1-1/2 Story	4	2200	861	3061	2200	1501	2200	3196	357

Table A.6. Energy consumption data converted to thermal conductance *UA*.

Home	Age	Style	UA	y-intercept	x-intercept	base temperature	Thermostat avg. setting
Number	(years)		(Btu/h·°F)	(Btu/h)	(°F-day/day)	(°F)	(°F)
A-1	20	Ranch	473.642	-2374.690	5.014	60.0	73
A-3	2	Ranch	434.018	1164.491	-2.683	67.7	69.5
A-4	7	Ranch	25.354	6988.052	-275.624	340.6	68.5
A-6	3	Ranch	347.708	-1345.401	3.869	61.1	64
A-7	7	Ranch	575.676	-4600.009	7.991	57.0	65.5
A-9	7	Ranch	447.655	-827.275	1.848	63.2	68
B-1	2	Ranch	430.042	-2360.991	5.490	59.5	61.5
B-3	2	Ranch	585.421	-2290.104	3.912	61.1	68
B-6	9	Ranch	400.935	-402.927	1.005	64.0	72
B-8	6	Ranch	622.743	-2405.682	3.863	61.1	71
C-2	2.5	Ranch	588.147	3480.434	-5.918	70.9	71.5
C-3	11	Ranch	466.047	4668.106	-10.016	75.0	68
C-4	4.5	Ranch	493.879	1105.707	-2.239	67.2	67
C-7	2	Ranch	297.617	1569.214	-5.273	70.3	70
C-8	12	Ranch	315.863	1346.388	-4.263	69.3	70
C-9	2	Ranch	479.633	688.651	-1.436	66.4	68.5
A-2	4	2-Story	712.634	-2825.274	3.965	61.0	70
B-4	12	2-Story	619.181	-2940.696	4.749	60.3	73
B-5	2	2-Story	476.590	-546.959	1.148	63.9	68
B-9	6.5	2-Story	788.038	-852.644	1.082	63.9	68.5
C-1	2	2-Story	642.613	-2652.169	4.127	60.9	68
C-5	10	2-Story	687.423	-3984.574	5.796	59.2	69
C-6	7	2-Story	381.499	-935.776	2.453	62.5	65
C-10	12	2-Story	491.751	1118.939	-2.275	67.3	67
A-5	9	Split-Level	395.014	-320.863	0.812	64.2	66.5
A-8	13	Split-Level	372.094	-2146.542	5.769	59.2	70
A-10	9	1-1/2 Story	475.898	-1193.783	2.508	62.5	66.75
B-2	2	1-1/2 Story	727.461	-2123.300	2.919	62.1	63.5
B-7	8	Split-Level	423.320	-2073.495	4.898	60.1	70
B-10	3	1-1/2 Story	1190.279	-3832.822	3.220	61.8	66

Table A.7. Energy consumption for natural gas for one- and two-year HDD periods.

Home Number	Age (years)	Style	Gas (1-year) total Btu	Gas (1-year) Cost	Gas (2-year) total Btu	Gas (2-year) Cost
A-1	20	Ranch	70,500,000	$705	143,900,000	$1,439
A-3	2	Ranch	86,400,000	$864	174,500,000	$1,745
A-4	7	Ranch	50,900,000	$509	123,900,000	$1,239
A-6	3	Ranch	54,700,000	$547	111,100,000	$1,111
A-7	7	Ranch	74,400,000	$744	154,500,000	$1,545
A-9	7	Ranch	75,300,000	$753	143,000,000	$1,430
B-1	2	Ranch	55,400,000	$554	108,400,000	$1,084
B-3	2	Ranch	81,300,000	$813	160,600,000	$1,606
B-6	9	Ranch	62,100,000	$621	122,600,000	$1,226
B-8	6	Ranch	86,200,000	$862	177,600,000	$1,776
C-2	2.5	Ranch	96,000,000	$960	203,500,000	$2,035
C-3	11	Ranch	92,800,000	$928	183,800,000	$1,838
C-4	4.5	Ranch	72,300,000	$723	144,000,000	$1,440
C-7	2	Ranch	50,500,000	$505	124,800,000	$1,248
C-8	12	Ranch	51,800,000	$518	103,200,000	$1,032
C-9	2	Ranch	70,600,000	$706	137,200,000	$1,372
A-2	4	2-Story	110,900,000	$1,109	215,800,000	$2,158
B-4	12	2-Story	79,000,000	$790	123,300,000	$1,233
B-5	2	2-Story	70,700,000	$707	138,300,000	$1,383
B-9	6.5	2-Story	121,800,000	$1,218	240,700,000	$2,407
C-1	2	2-Story	74,000,000	$740	142,700,000	$1,427
C-5	10	2-Story	93,400,000	$934	177,900,000	$1,779
C-6	7	2-Story	64,400,000	$644	128,900,000	$1,289
C-10	12	2-Story	75,300,000	$753	144,000,000	$1,440
A-5	9	Split-Level	70,700,000	$707	136,800,000	$1,368
A-8	13	Split-Level	52,900,000	$529	103,200,000	$1,032
A-10	9	1-1/2 Story	78,200,000	$782	150,100,000	$1,501
B-2	2	1-1/2 Story	105,300,000	$1,053	202,500,000	$2,025
B-7	8	Split-Level	55,100,000	$551	107,700,000	$1,077
B-10	3	1-1/2 Story	169,600,000	$1,696	337,900,000	$3,379

Table A.8. Energy consumption for electricity for one- and two-year CDD periods.

Home Number	Age (years)	Style	Electric (1-year) total kW·h	Electric (1-year) Cost	Electric (2-year) total kW·h	Electric (2-year) Cost
A-1	20	Ranch	3,869	$386.90	7,273	$727.30
A-3	2	Ranch	5,276	$527.60	11,260	$1,126.00
A-4	7	Ranch	4,296	$429.60	4,296	$429.60
A-6	3	Ranch	2,624	$262.40	6,933	$693.30
A-7	7	Ranch	5,774	$577.40	10,107	$1,010.70
A-9	7	Ranch	1,861	$186.10	3,109	$310.90
B-1	2	Ranch	1,816	$181.60	4,329	$432.90
B-3	2	Ranch	2,187	$218.70	4,995	$499.50
B-6	9	Ranch	4,463	$446.30	10,146	$1,014.60
B-8	6	Ranch	4,637	$463.70	9,691	$969.10
C-2	2.5	Ranch	4,186	$418.60	8,243	$824.30
C-3	11	Ranch	6,462	$646.20	6,462	$646.20
C-4	4.5	Ranch	2,394	$239.40	5,034	$503.40
C-7	2	Ranch	2,682	$268.20	5,326	$532.60
C-8	12	Ranch	3,560	$356.00	6,545	$654.50
C-9	2	Ranch	1,830	$183.00	4,030	$403.00
A-2	4	2-Story	3,983	$398.30	8,181	$818.10
B-4	12	2-Story	7,852	$785.20	15,389	$1,538.90
B-5	2	2-Story	2,591	$259.10	5,489	$548.90
B-9	6.5	2-Story	4,547	$454.70	9,928	$992.80
C-1	2	2-Story	4,632	$463.20	8,767	$876.70
C-5	10	2-Story	3,818	$381.80	8,382	$838.20
C-6	7	2-Story	5,645	$564.50	5,645	$564.50
C-10	12	2-Story	5,221	$522.10	10,223	$1,022.30
A-5	9	Split-Level	2,268	$226.80	5,050	$505.00
A-8	13	Split-Level	6,357	$635.70	13,086	$1,308.60
A-10	9	1-1/2 Story	3,799	$379.90	7,375	$737.50
B-2	2	1-1/2 Story	4,661	$466.10	8,450	$845.00
B-7	8	Split-Level	2,979	$297.90	5,956	$595.60
B-10	3	1-1/2 Story	6,568	$656.80	13,842	$1,384.20

Appendix B

Table B.1a. Natural gas data for Home A-1 (ranch).

Reading Date	Therms	cycle days	day	Btu/sqft-day	kWh/sqft-day	HDD/day	Btu/h	Btu (HDD)	Btu (HDD)
01/24/02	157	30	9	346.12	0.1014	54.03		15,700,000	
02/22/02	104	29	39	237.18	0.0695	43.51		10,400,000	
03/22/02	118	28	67	278.72	0.0817	33.35		11,800,000	
04/22/02	73	31	97	155.74	0.0456	22.83		7,300,000	
05/24/02	38	32	128	78.54	0.0230	11.60		3,800,000	
06/25/02	14	32	160	28.94	0.0085	0.00			
07/25/02	13	30	191	28.66	0.0084	0.00			
08/23/02	13	29	221	29.65	0.0087	0.00			
09/24/02	14	32	251	28.94	0.0085	6.78	1822.92	1,400,000	1,400,000
10/23/02	34	29	282	77.54	0.0227	16.70	4885.06	3,400,000	3,400,000
11/21/02	78	29	311	177.89	0.0521	26.14	11206.90	7,800,000	7,800,000
12/23/02	114	32	341	235.62	0.0690	36.06	14843.75	11,400,000	11,400,000
01/24/03	140	32	373	289.35	0.0848	46.48	18229.17	14,000,000	14,000,000
02/21/03	130	28	403	307.07	0.0900	44.88	19345.24	13,000,000	13,000,000
03/24/03	116	31	433	247.48	0.0725	34.70	15591.40	11,600,000	11,600,000
04/23/03	59	30	463	130.07	0.0381	24.17	8194.44	5,900,000	5,900,000
05/22/03	20	29	493	45.61	0.0134	13.99	2873.56	2,000,000	2,000,000
06/24/03	15	33	524	30.06	0.0088	0.00			
07/23/03	15	29	555	34.21	0.0100	0.00			
08/22/03	12	30	584	26.46	0.0078	0.00			
09/24/03	13	33	616	26.05	0.0076	4.43		1,300,000	
10/23/03	13	29	647	29.65	0.0087	15.09		1,300,000	
11/21/03	65	29	676	148.24	0.0434	25.06		6,500,000	
12/23/03	153	32	706	316.22	0.0927	35.54		15,300,000	
						UA =	**473.642**	**143,900,000**	**70,500,000**
							-2374.690		

Table B.1b. Electricity data for Home A-1 (ranch).

Reading Date	kWh	cycle days	day	Btu/sqft-day	kWh/sqft-day	kWh (CDD)	kWh (CDD)
02/08/02	503	30	24	37.85	0.0111		
03/11/02	554	31	55	40.34	0.0118		
04/10/02	526	30	85	39.58	0.0116		
05/13/02	563	33	117	38.51	0.0113		
06/12/02	644	30	148	48.46	0.0142		
07/11/02	1081	29	178	84.14	0.0247	1081	
08/12/02	1322	32	208	93.25	0.0273	1322	
09/12/02	1001	31	240	72.89	0.0214	1001	
10/11/02	556	29	270	43.28	0.0127		
11/13/02	591	33	301	40.43	0.0118		
12/10/02	622	27	331	52.00	0.0152		
01/14/03	908	35	362	58.56	0.0172		
02/12/03	552	29	394	42.97	0.0126		
03/12/03	405	28	422	32.65	0.0096		
04/10/03	656	29	451	51.06	0.0150		
05/12/03	647	32	481	45.64	0.0134		
06/12/03	513	31	513	37.35	0.0109		
07/10/03	1303	28	542	105.04	0.0308	1303	1303
08/14/03	1307	35	574	84.29	0.0247	1307	1307
09/12/03	1259	29	606	98.00	0.0287	1259	1259
10/10/03	535	28	634	43.13	0.0126		
11/13/03	615	34	665	40.83	0.0120		
12/11/03	646	28	696	52.08	0.0153		
01/13/04	995	33	727	68.06	0.0199		
						7273	**3869**

Table B.2a. Natural gas data for Home A-2 (2-story).

Reading Date	Therms	cycle days	day	Btu/sqft-day	kWh/sqft-day	HDD/day	Btu/h	Btu (HDD)	Btu (HDD)
01/24/02	233	30	9	353.03	0.1034	54.03		23,300,000	
02/25/02	157	32	40	223.01	0.0653	42.98		15,700,000	
03/22/02	162	25	69	294.55	0.0863	32.82		16,200,000	
04/22/02	102	31	97	149.56	0.0438	22.83		10,200,000	
05/24/02	55	32	128	78.13	0.0229	11.60		5,500,000	
06/25/02	22	32	160	31.25	0.0092	0.00			
07/25/02	15	30	191	22.73	0.0067	0.00			
08/22/02	11	28	220	17.86	0.0052	0.00			
09/24/02	17	33	251	23.42	0.0069	6.62	2146.46	1,700,000	1,700,000
10/23/02	56	29	282	87.77	0.0257	16.70	8045.98	5,600,000	5,600,000
11/21/02	122	29	311	191.22	0.0560	26.14	17528.74	12,200,000	12,200,000
12/23/02	187	32	341	265.63	0.0778	36.06	24348.96	18,700,000	18,700,000
01/24/03	221	32	373	313.92	0.0920	46.48	28776.04	22,100,000	22,100,000
02/21/03	196	28	403	318.18	0.0932	44.88	29166.67	19,600,000	19,600,000
03/24/03	170	31	433	249.27	0.0730	34.70	22849.46	17,000,000	17,000,000
04/23/03	90	30	463	136.36	0.0400	24.17	12500.00	9,000,000	9,000,000
05/22/03	50	29	493	78.37	0.0230	13.99	7183.91	5,000,000	5,000,000
06/24/03	28	33	524	38.57	0.0113	0.00			
07/23/03	20	29	555	31.35	0.0092	0.00			
08/22/03	10	30	584	15.15	0.0044	0.00			
09/24/03	13	33	616	17.91	0.0052	4.43		1,300,000	
10/23/03	38	29	647	59.56	0.0175	15.09		3,800,000	
11/21/03	108	29	676	169.28	0.0496	25.06		10,800,000	
12/22/03	181	31	706	265.40	0.0778	35.37		18,100,000	
						UA =	**712.634**	**215,800,000**	**110,900,000**
							-2825.274		

Table B.2b. Electricity data for Home A-2 (2-story).

Reading Date	kWh	cycle days	day	Btu/sqft-day	kWh/sqft-day	kWh (CDD)	kWh (CDD)
02/08/02	833	30	24	43.08	0.0126		
03/08/02	855	28	53	47.37	0.0139		
04/09/02	933	32	83	45.23	0.0133		
05/10/02	789	31	115	39.48	0.0116		
06/10/02	729	31	146	36.48	0.0107		
07/10/02	1620	30	176	83.77	0.0245	1620	
08/12/02	1281	33	208	60.22	0.0176	1281	
09/12/02	1297	31	240	64.91	0.0190	1297	
10/10/02	725	28	269	40.17	0.0118		
11/12/02	999	33	300	46.96	0.0138		
12/09/02	1066	27	330	61.25	0.0179		
01/10/03	1520	32	359	73.69	0.0216		
02/10/03	1191	31	391	59.60	0.0175		
03/10/03	983	28	420	54.46	0.0160		
04/09/03	902	30	449	46.64	0.0137		
05/09/03	814	30	479	42.09	0.0123		
06/11/03	790	33	511	37.14	0.0109		
07/09/03	1340	28	541	74.24	0.0218	1340	1340
08/12/03	1153	34	572	52.61	0.0154	1153	1153
09/10/03	1490	29	604	79.71	0.0234	1490	1490
10/08/03	753	28	632	41.72	0.0122		
11/10/03	1099	33	663	51.66	0.0151		
12/09/03	1133	29	694	60.61	0.0178		
01/09/04	1586	31	724	79.37	0.0233		
						8181	**3983**

Table B.3a. Natural gas data for Home A-3 (ranch).

Reading Date	Therms	cycle days	day	Btu/sqft-day	kWh/sqft-day	HDD/day	Btu/h	Btu (HDD)	Btu (HDD)
01/24/02	171	30	9	308.11	0.0903	54.03		17,100,000	
02/22/02	124	29	39	231.13	0.0677	43.51		12,400,000	
03/22/02	118	28	67	227.80	0.0667	33.35		11,800,000	
04/22/02	118	31	97	205.75	0.0603	22.83		11,800,000	
05/24/02	66	32	128	111.49	0.0327	11.60		6,600,000	
06/25/02	41	32	160	69.26	0.0203	0.00			
07/25/02	33	30	191	59.46	0.0174	0.00			
08/22/02	31	28	220	59.85	0.0175	0.00			
09/24/02	34	33	251	55.69	0.0163	6.62	4292.93	3,400,000	3,400,000
10/23/02	46	29	282	85.74	0.0251	16.70	6609.20	4,600,000	4,600,000
11/20/02	86	28	310	166.02	0.0486	25.98	12797.62	8,600,000	8,600,000
12/23/02	127	33	341	208.03	0.0610	35.90	16035.35	12,700,000	12,700,000
01/23/03	146	31	373	254.58	0.0746	46.31	19623.66	14,600,000	14,600,000
02/21/03	149	29	403	277.73	0.0814	45.05	21408.05	14,900,000	14,900,000
03/24/03	137	31	433	238.88	0.0700	34.70	18413.98	13,700,000	13,700,000
04/23/03	87	30	463	156.76	0.0459	24.17	12083.33	8,700,000	8,700,000
05/22/03	52	29	493	96.92	0.0284	13.99	7471.26	5,200,000	5,200,000
06/24/03	40	33	524	65.52	0.0192	0.00			
07/23/03	31	29	555	57.78	0.0169	0.00			
08/22/03	31	30	584	55.86	0.0164	0.00			
09/24/03	37	33	616	60.61	0.0178	4.43		3,700,000	
10/23/03	36	29	647	67.10	0.0197	15.09		3,600,000	
11/21/03	79	29	676	147.25	0.0431	25.06		7,900,000	
12/23/03	132	32	706	222.97	0.0653	35.54		13,200,000	
						UA =	**434.018**	**174,500,000**	**86,400,000**
							1164.491		

Table B.3b. Electricity data for Home A-3 (ranch).

Reading Date	kWh	cycle days	day	Btu/sqft-day	kWh/sqft-day	kWh (CDD)	kWh (CDD)
02/08/02	1306	30	24	80.31	0.0235		
03/08/02	1247	28	53	82.16	0.0241		
04/09/02	1358	32	83	78.29	0.0229		
05/10/02	1200	31	115	71.41	0.0209		
06/10/02	1395	31	146	83.02	0.0243		
07/11/02	2035	31	177	121.11	0.0355	2035	
08/13/02	2075	33	209	116.00	0.0340	2075	
09/11/02	1874	29	240	119.22	0.0349	1874	
10/11/02	1290	30	269	79.33	0.0232		
11/14/02	1370	34	301	74.34	0.0218		
12/10/02	1216	26	331	86.28	0.0253		
01/13/03	1391	34	361	75.48	0.0221		
02/12/03	1369	30	393	84.19	0.0247		
03/12/03	1176	28	422	77.48	0.0227		
04/09/03	1122	28	450	73.93	0.0217		
05/12/03	1261	33	481	70.50	0.0207		
06/12/03	1104	31	513	65.70	0.0193		
07/11/03	1571	29	543	99.94	0.0293	1571	1571
08/14/03	1864	34	574	101.14	0.0296	1864	1864
09/11/03	1841	28	605	121.30	0.0355	1841	1841
10/10/03	1168	29	634	74.30	0.0218		
11/13/03	1434	34	665	77.81	0.0228		
12/11/03	1342	28	696	88.42	0.0259		
01/12/04	1645	32	726	94.84	0.0278		
						11260	**5276**

Table B.4a. Natural gas data for Home A-4 (ranch).

Reading Date	Therms	cycle days	day	Btu/sqft-day	kWh/sqft-day	HDD/day	Btu/h	Btu (HDD)	Btu (HDD)
01/31/02	29	30	16	53.70	0.0157	51.53		2,900,000	
02/28/02	29	28	45	57.54	0.0169	41.19		2,900,000	
03/31/02	182	31	75	326.16	0.0956	30.68		18,200,000	
04/30/02	81	30	105	150.00	0.0440	19.80		8,100,000	
05/31/02	58	31	136	103.94	0.0305	8.93		5,800,000	
07/02/02	20	32	167	34.72	0.0102	0.00			
07/31/02	14	29	198	26.82	0.0079	0.00			
09/03/02	16	34	229	26.14	0.0077	0.00			
09/30/02	21	27	260	43.21	0.0127	9.54	3240.74	2,100,000	2,100,000
10/29/02	70	29	288	134.10	0.0393	18.65	10057.47	7,000,000	7,000,000
12/02/02	139	34	319	227.12	0.0665	28.91	17034.31	13,900,000	13,900,000
01/02/03	28	31	352	50.18	0.0147	39.48	3763.44	2,800,000	2,800,000
01/31/03	61	29	382	116.86	0.0342	52.30	8764.37	6,100,000	6,100,000
03/03/03	59	31	412	105.73	0.0310	41.95	7930.11	5,900,000	5,900,000
04/01/03	22	29	442	42.15	0.0123	31.59	3160.92	2,200,000	2,200,000
04/30/03	58	29	471	111.11	0.0326	21.58	8333.33	5,800,000	5,800,000
05/30/03	51	30	500	94.44	0.0277	11.40	7083.33	5,100,000	5,100,000
06/30/03	20	31	531	35.84	0.0105	0.00			
07/30/03	15	30	561	27.78	0.0081	0.00			
08/28/03	14	29	591	26.82	0.0079	0.00			
09/29/03	4	32	621	6.94	0.0020	6.32		400,000	
10/28/03	54	29	652	103.45	0.0303	16.81		5,400,000	
12/01/03	140	34	683	228.76	0.0670	27.63		14,000,000	
01/02/04	153	32	716	265.63	0.0778	38.98		15,300,000	
						UA =	**25.354**	**123,900,000**	**50,900,000**
							6988.052		

Table B.4b. Electricity data for Home A-4 (ranch).

Reading Date	kWh	cycle days	day	Btu/sqft-day	kWh/sqft-day	kWh (CDD)	kWh (CDD)
01/31/02	143	30	16	9.04	0.0026		
02/28/02	139	28	45	9.41	0.0028		
03/31/02	520	31	75	31.81	0.0093		
04/30/02	417	30	105	26.36	0.0077		
05/31/02	444	31	136	27.16	0.0080		
07/02/02	775	32	167	45.92	0.0135	775	775
07/31/02	732	29	198	47.86	0.0140	732	732
09/03/02	694	34	229	38.70	0.0113	694	694
09/30/02	532	27	260	37.36	0.0109		
10/29/02	432	29	288	28.25	0.0083		
12/02/02	641	34	319	35.75	0.0105		
01/02/03	197	31	352	12.05	0.0035		
01/31/03	185	29	382	12.10	0.0035		
03/03/03	191	31	412	11.68	0.0034		
04/01/03	163	29	442	10.66	0.0031		
04/30/03	346	29	471	22.62	0.0066		
05/30/03	502	30	500	31.73	0.0093		
06/30/03	476	31	531	29.11	0.0085	476	476
07/30/03	785	30	561	49.61	0.0145	785	785
08/28/03	834	29	591	54.53	0.0160	834	834
09/29/03	270	32	621	16.00	0.0047		
10/28/03	425	29	652	27.79	0.0081		
12/01/03	574	34	683	32.01	0.0094		
01/02/04	541	32	716	32.06	0.0094		
						4296	**4296**

Table B.5a. Natural gas data for Home A-5 (split-level).

Reading Date	Therms	cycle days	day	Btu/sqft-day	kWh/sqft-day	HDD/day	Btu/h	Btu (HDD)	Btu (HDD)
02/01/02	104	30	17	249.04	0.0730	51.18		10,400,000	
03/01/02	101	28	46	259.13	0.0759	40.84		10,100,000	
04/01/02	97	31	76	224.79	0.0659	30.32		9,700,000	
05/01/02	51	30	106	122.13	0.0358	19.45		5,100,000	
06/01/02	35	31	137	81.11	0.0238	8.57		3,500,000	
07/08/02	33	37	171	64.07	0.0188	0.00			
08/02/02	26	25	202	74.71	0.0219	0.00			
09/05/02	32	34	231	67.61	0.0198	0.00			
10/03/02	22	28	262	56.44	0.0165	10.36	3273.81	2,200,000	2,200,000
11/01/02	47	29	291	116.43	0.0341	19.63	6752.87	4,700,000	4,700,000
12/04/02	97	33	322	211.16	0.0619	29.72	12247.47	9,700,000	9,700,000
01/06/03	117	33	355	254.70	0.0746	40.46	14772.73	11,700,000	11,700,000
02/04/03	132	29	386	326.99	0.0958	50.92	18965.52	13,200,000	13,200,000
03/05/03	126	29	415	312.13	0.0915	40.91	18103.45	12,600,000	12,600,000
04/03/03	76	29	444	188.27	0.0552	30.90	10919.54	7,600,000	7,600,000
05/02/03	56	29	473	138.72	0.0406	20.89	8045.98	5,600,000	5,600,000
06/03/03	34	32	503	76.33	0.0224	10.37	4427.08	3,400,000	3,400,000
07/02/03	23	29	534	56.98	0.0167	0.00			
08/01/03	24	30	563	57.47	0.0168	0.00			
09/03/03	26	33	595	56.60	0.0166	0.00			
10/01/03	21	28	625	53.88	0.0158	7.70		2,100,000	
10/30/03	34	29	654	84.23	0.0247	17.50		3,400,000	
12/02/03	93	33	685	202.46	0.0593	28.15		9,300,000	
01/05/04	125	34	718	264.11	0.0774	39.66		12,500,000	
						UA =	**395.014**	**136,800,000**	**70,700,000**
							-320.863		

Table B.5b. Electricity data for Home A-5 (split-level).

Reading Date	kWh	cycle days	day	Btu/sqft-day	kWh/sqft-day	kWh (CDD)	kWh (CDD)
02/01/02	532	30	17	43.48	0.0127		
03/01/02	478	28	46	41.86	0.0123		
04/01/02	516	31	76	40.81	0.0120		
05/01/02	453	30	106	37.02	0.0108		
06/01/02	562	31	137	44.45	0.0130		
07/08/02	1015	37	171	67.26	0.0197	1015	
08/02/02	874	25	202	85.72	0.0251	874	
09/05/02	893	34	231	64.40	0.0189	893	
10/03/02	482	28	262	42.21	0.0124		
11/01/02	466	29	291	39.40	0.0115		
12/04/02	626	33	322	46.51	0.0136		
01/06/03	687	33	355	51.04	0.0150		
02/04/03	522	29	386	44.13	0.0129		
03/05/03	475	29	415	40.16	0.0118		
04/03/03	447	29	444	37.79	0.0111		
05/02/03	472	29	473	39.91	0.0117		
06/03/03	482	32	503	36.93	0.0108		
07/02/03	569	29	534	48.11	0.0141	569	569
08/01/03	832	30	563	68.00	0.0199	832	832
09/03/03	867	33	595	64.42	0.0189	867	867
10/01/03	513	28	625	44.92	0.0132		
10/30/03	487	29	654	41.17	0.0121		
12/02/03	710	33	685	52.75	0.0155		
01/05/04	775	34	718	55.89	0.0164		
						5050	**2268**

Table B.6a. Natural gas data for Home A-6 (ranch).

Reading Date	Therms	cycle days	day	Btu/sqft-day	kWh/sqft-day	HDD/day	Btu/h	Btu (HDD)	Btu (HDD)
01/25/02	114	30	10	211.11	0.0619	53.67		11,400,000	
02/25/02	92	31	41	164.87	0.0483	42.80		9,200,000	
03/27/02	101	30	71	187.04	0.0548	31.92		10,100,000	
04/24/02	44	28	100	87.30	0.0256	21.59		4,400,000	
05/24/02	34	30	129	62.96	0.0184	11.25		3,400,000	
06/24/02	20	31	160	35.84	0.0105	0.00			
07/24/02	20	30	190	37.04	0.0109	0.00			
08/22/02	16	29	220	30.65	0.0090	0.00			
09/23/02	12	32	250	20.83	0.0061	6.45	1562.50	1,200,000	1,200,000
10/22/02	21	29	281	40.23	0.0118	16.38	3017.24	2,100,000	2,100,000
11/20/02	59	29	310	113.03	0.0331	25.81	8477.01	5,900,000	5,900,000
12/23/02	86	33	341	144.78	0.0424	35.90	10858.59	8,600,000	8,600,000
01/24/03	111	32	373	192.71	0.0565	46.48	14453.13	11,100,000	11,100,000
02/28/03	123	35	407	195.24	0.0572	43.67	14642.86	12,300,000	12,300,000
04/01/03	76	32	440	131.94	0.0387	32.11	9895.83	7,600,000	7,600,000
04/29/03	35	28	470	69.44	0.0203	21.76	5208.33	3,500,000	3,500,000
05/29/03	24	30	499	44.44	0.0130	11.75	3333.33	2,400,000	2,400,000
06/27/03	13	29	529	24.90	0.0073	0.00			
07/29/03	17	32	559	29.51	0.0086	0.00			
08/27/03	12	29	590	22.99	0.0067	0.00			
09/26/03	12	30	619	22.22	0.0065	5.64		1,200,000	
10/27/03	20	31	650	35.84	0.0105	16.12		2,000,000	
11/25/03	54	29	680	103.45	0.0303	26.43		5,400,000	
12/30/03	93	35	712	147.62	0.0433	37.43		9,300,000	
						UA =	**347.708**	**111,100,000**	**54,700,000**
							-1345.401		

Table B.6b. Electricity data for Home A-6 (ranch).

Reading Date	kWh	cycle days	day	Btu/sqft-day	kWh/sqft-day	kWh (CDD)	kWh (CDD)
01/25/02	1054	30	10	66.62	0.0195		
02/25/02	822	31	41	50.28	0.0147		
03/27/02	753	30	71	47.59	0.0139		
04/24/02	788	28	100	53.36	0.0156		
05/24/02	823	30	129	52.02	0.0152		
06/24/02	1166	31	160	71.32	0.0209	1166	
07/24/02	1673	30	190	105.74	0.0310	1673	
08/22/02	1470	29	220	96.11	0.0282	1470	
09/23/02	1054	32	250	62.45	0.0183		
10/22/02	663	29	281	43.35	0.0127		
11/20/02	622	29	310	40.67	0.0119		
12/23/02	898	33	341	51.60	0.0151		
01/24/03	800	32	373	47.40	0.0139		
02/28/03	751	35	407	40.68	0.0119		
04/01/03	737	32	440	43.67	0.0128		
04/29/03	621	28	470	42.05	0.0123		
05/29/03	630	30	499	39.82	0.0117		
06/27/03	681	29	529	44.53	0.0130	681	681
07/29/03	1030	32	559	61.03	0.0179	1030	1030
08/27/03	913	29	590	59.69	0.0175	913	913
09/26/03	657	30	619	41.52	0.0122		
10/27/03	620	31	650	37.92	0.0111		
11/25/03	552	29	680	36.09	0.0106		
12/30/03	840	35	712	45.51	0.0133		
						6933	**2624**

Table B.7a. Natural gas data for Home A-7 (ranch).

Reading Date	Therms	cycle days	day	Btu/sqft-day	kWh/sqft-day	HDD/day	Btu/h	Btu (HDD)	Btu (HDD)
01/24/02	186	30	9	288.10	0.0844	54.03		18,600,000	
02/22/02	130	29	39	208.31	0.0610	43.51		13,000,000	
03/26/02	158	32	69	229.44	0.0672	32.64		15,800,000	
04/23/02	57	28	99	94.60	0.0277	21.94		5,700,000	
05/23/02	50	30	128	77.45	0.0227	11.60		5,000,000	
06/24/02	28	32	159	40.66	0.0119	0.00			
07/24/02	25	30	190	38.72	0.0113	0.00			
08/22/02	6	29	220	9.61	0.0028	0.00			
09/23/02	0	32	250	0.00	0.0000	6.45	0.00	0	0
10/21/02	28	28	280	46.47	0.0136	16.21	4166.67	2,800,000	2,800,000
11/20/02	88	30	309	136.31	0.0399	25.65	12222.22	8,800,000	8,800,000
12/20/02	112	30	339	173.48	0.0508	35.41	15555.56	11,200,000	11,200,000
01/24/03	177	35	372	235.00	0.0689	45.99	21071.43	17,700,000	17,700,000
02/24/03	163	31	405	244.33	0.0716	44.36	21908.60	16,300,000	16,300,000
03/25/03	106	29	435	169.85	0.0498	34.01	15229.89	10,600,000	10,600,000
04/24/03	51	30	464	79.00	0.0231	23.83	7083.33	5,100,000	5,100,000
05/22/03	19	28	493	31.53	0.0092	13.82	2827.38	1,900,000	1,900,000
06/23/03	8	32	523	11.62	0.0034	0.00			
07/24/03	7	31	555	10.49	0.0031	0.00			
08/22/03	7	29	585	11.22	0.0033	0.00			
09/23/03	8	32	615	11.62	0.0034	4.26		800,000	
10/23/03	14	30	646	21.69	0.0064	14.92		1,400,000	
11/20/03	67	28	675	111.19	0.0326	24.88		6,700,000	
12/22/03	131	32	705	190.23	0.0557	35.20		13,100,000	
						UA =	**575.676**	**154,500,000**	**74,400,000**
							-4600.009		

Table B.7b. Electricity data for Home A-7 (ranch).

Reading Date	kWh	cycle days	day	Btu/sqft-day	kWh/sqft-day	kWh (CDD)	kWh (CDD)
01/31/02	834	30	16	44.09	0.0129		
02/28/02	983	28	45	55.68	0.0163		
03/29/02	1142	29	74	62.45	0.0183		
04/30/02	1151	32	104	57.04	0.0167		
05/31/02	760	31	136	38.88	0.0114		
06/28/02	1252	28	165	70.91	0.0208	1252	
07/31/02	1857	33	196	89.25	0.0261	1857	
08/30/02	1224	30	227	64.71	0.0190	1224	
09/30/02	1468	31	258	75.10	0.0220		
10/31/02	1095	31	289	56.02	0.0164		
11/30/02	1195	30	319	63.17	0.0185		
12/30/02	1469	30	349	77.66	0.0228		
01/30/03	1276	31	380	65.28	0.0191		
02/28/03	1065	29	410	58.24	0.0171		
03/31/03	1098	31	440	56.17	0.0165		
04/30/03	1196	30	470	63.23	0.0185		
05/30/03	1121	30	500	59.26	0.0174		
06/30/03	1815	31	531	92.85	0.0272	1815	1815
07/31/03	1962	31	562	100.38	0.0294	1962	1962
08/29/03	1997	29	592	109.21	0.0320	1997	1997
09/30/03	1387	32	622	68.74	0.0201		
10/31/03	1104	31	654	56.48	0.0165		
12/01/03	1194	31	685	61.08	0.0179		
12/31/03	1062	30	715	56.14	0.0164		
						10107	**5774**

Table B.8a. Natural gas data for Home A-8 (split-level).

Reading Date	Therms	cycle days	day	Btu/sqft-day	kWh/sqft-day	HDD/day	Btu/h	Btu (HDD)	Btu (HDD)
01/17/02	104	30	2	266.67	0.0781	56.52		10,400,000	
02/18/02	88	32	33	211.54	0.0620	45.47		8,800,000	
03/19/02	89	29	64	236.07	0.0692	34.60		8,900,000	
04/17/02	57	29	93	151.19	0.0443	24.26		5,700,000	
05/16/02	27	29	122	71.62	0.0210	13.92		2,700,000	
06/19/02	12	34	153	27.15	0.0080	0.00			
07/17/02	7	28	184	19.23	0.0056	0.00			
08/15/02	8	29	213	21.22	0.0062	0.00			
09/18/02	8	34	244	18.10	0.0053	4.50	980.39	800,000	800,000
10/16/02	13	28	275	35.71	0.0105	14.59	1934.52	1,300,000	1,300,000
11/14/02	46	29	304	122.02	0.0358	23.86	6609.20	4,600,000	4,600,000
12/17/02	80	33	335	186.48	0.0546	33.95	10101.01	8,000,000	8,000,000
01/20/03	100	34	368	226.24	0.0663	44.85	12254.90	10,000,000	10,000,000
02/21/03	127	32	401	305.29	0.0894	45.57	16536.46	12,700,000	12,700,000
03/20/03	87	27	431	247.86	0.0726	35.39	13425.93	8,700,000	8,700,000
04/18/03	45	29	459	119.36	0.0350	25.73	6465.52	4,500,000	4,500,000
05/19/03	23	31	489	57.07	0.0167	15.37	3091.40	2,300,000	2,300,000
06/18/03	7	30	519	17.95	0.0053	0.00			
07/18/03	8	30	549	20.51	0.0060	0.00			
08/18/03	9	31	580	22.33	0.0065	0.00			
09/17/03	7	30	610	17.95	0.0053	2.54		700,000	
10/16/03	11	29	640	29.18	0.0085	12.68		1,100,000	
11/14/03	37	29	669	98.14	0.0288	22.65		3,700,000	
12/17/03	83	33	700	193.47	0.0567	33.31		8,300,000	
						UA =	**372.094**	**103,200,000**	**52,900,000**
							-2146.542		

Table B.8b. Electricity data for Home A-8 (split-level).

Reading Date	kWh	cycle days	day	Btu/sqft-day	kWh/sqft-day	kWh (CDD)	kWh (CDD)
01/17/02	1957	30	2	171.26	0.0502		
02/18/02	1458	32	33	119.62	0.0350		
03/19/02	1461	29	64	132.26	0.0388		
04/17/02	1368	29	93	123.84	0.0363		
05/16/02	1283	29	122	116.15	0.0340		
06/19/02	1614	34	153	124.63	0.0365	1614	
07/17/02	2654	28	184	248.85	0.0729	2654	
08/15/02	2461	29	213	222.79	0.0653	2461	
09/18/02	2254	34	244	174.05	0.0510		
10/16/02	943	28	275	88.42	0.0259		
11/14/02	1115	29	304	100.94	0.0296		
12/17/02	1609	33	335	128.01	0.0375		
01/20/03	1924	34	368	148.56	0.0435		
02/21/03	1439	32	401	118.06	0.0346		
03/20/03	1160	27	431	112.79	0.0330		
04/18/03	1180	29	459	106.83	0.0313		
05/19/03	1122	31	489	95.02	0.0278		
06/18/03	1371	30	519	119.98	0.0352	1371	1371
07/18/03	2292	30	549	200.58	0.0588	2292	2292
08/18/03	2694	31	580	228.15	0.0668	2694	2694
09/17/03	1953	30	610	170.91	0.0501		
10/16/03	973	29	640	88.09	0.0258		
11/14/03	1155	29	669	104.56	0.0306		
12/17/03	1608	33	700	127.93	0.0375		
						13086	**6357**

Table B.9a. Natural gas data for Home A-9 (ranch).

Reading Date	Therms	cycle days	day	Btu/sqft-day	kWh/sqft-day	HDD/day	Btu/h	Btu (HDD)	Btu (HDD)
01/17/02	136	30	2	298.25	0.0874	56.523		13,600,000	
02/18/02	108	32	33	222.04	0.0651	45.472		10,800,000	
03/19/02	113	29	64	256.35	0.0751	34.598		11,300,000	
04/17/02	78	29	93	176.95	0.0518	24.260		7,800,000	
05/16/02	45	29	122	102.09	0.0299	13.921		4,500,000	
06/19/02	28	34	153	54.18	0.0159	0.000			
07/17/02	10	28	184	23.50	0.0069	0.000			
08/15/02	12	29	213	27.22	0.0080	0.000			
09/17/02	15	33	244	29.90	0.0088	4.337	1893.94	1,500,000	1,500,000
10/16/02	26	29	275	58.98	0.0173	14.425	3735.63	2,600,000	2,600,000
11/14/02	72	29	304	163.34	0.0479	23.861	10344.83	7,200,000	7,200,000
12/17/02	116	33	335	231.26	0.0678	33.949	14646.46	11,600,000	11,600,000
01/20/03	144	34	368	278.64	0.0816	44.850	17647.06	14,400,000	14,400,000
02/21/03	153	32	401	314.56	0.0922	45.569	19921.88	15,300,000	15,300,000
03/20/03	110	27	431	268.03	0.0785	35.389	16975.31	11,000,000	11,000,000
04/18/03	71	29	459	161.07	0.0472	25.726	10201.15	7,100,000	7,100,000
05/19/03	46	31	489	97.62	0.0286	15.373	6182.80	4,600,000	4,600,000
06/18/03	18	30	519	39.47	0.0116	0.000			
07/18/03	15	30	549	32.89	0.0096	0.000			
08/18/03	13	31	580	27.59	0.0081	0.000			
09/17/03	11	30	610	24.12	0.0071	2.544		1,100,000	
10/16/03	23	29	640	52.18	0.0153	12.683		2,300,000	
11/14/03	62	29	669	140.65	0.0412	22.651		6,200,000	
12/17/03	101	33	700	201.36	0.0590	33.305		10,100,000	
						UA =	**447.655**	**143,000,000**	**75,300,000**
							-827.275		

Table B.9b. Electricity data for Home A-9 (ranch).

Reading Date	kWh	cycle days	day	Btu/sqft-day	kWh/sqft-day	kWh (CDD)	kWh (CDD)
01/17/02	653	30	2	48.87	0.0143		
02/18/02	495	32	33	34.73	0.0102		
03/19/02	452	29	64	35.00	0.0103		
04/17/02	431	29	93	33.37	0.0098		
05/16/02	397	29	122	30.74	0.0090		
06/19/02	408	34	153	26.94	0.0079	408	
07/17/02	439	28	184	35.20	0.0103	439	
08/15/02	401	29	213	31.05	0.0091	401	
09/17/02	389	33	244	26.47	0.0078		
10/16/02	336	29	275	26.02	0.0076		
11/14/02	373	29	304	28.88	0.0085		
12/17/02	532	33	335	36.20	0.0106		
01/20/03	574	34	368	37.91	0.0111		
02/21/03	454	32	401	31.86	0.0093		
03/20/03	360	27	431	29.94	0.0088		
04/18/03	546	29	459	42.27	0.0124		
05/19/03	242	31	489	17.53	0.0051		
06/18/03	459	30	519	34.35	0.0101	459	459
07/18/03	689	30	549	51.57	0.0151	689	689
08/18/03	713	31	580	51.64	0.0151	713	713
09/17/03	653	30	610	48.87	0.0143		
10/16/03	455	29	640	35.23	0.0103		
11/14/03	450	29	669	34.84	0.0102		
12/17/03	574	33	700	39.06	0.0114		
						3109	**1861**

Table B.10a. Natural gas data for Home A-10 (1-1/2 story).

Reading Date	Therms	cycle days	day	Btu/sqft-day	kWh/sqft-day	HDD/day	Btu/h	Btu (HDD)	Btu (HDD)
01/17/02	139	30	2	243.86	0.0715	56.52		13,900,000	
02/18/02	124	32	33	203.95	0.0598	45.47		12,400,000	
03/19/02	109	29	64	197.82	0.0580	34.60		10,900,000	
04/17/02	78	29	93	141.56	0.0415	24.26		7,800,000	
05/16/02	58	29	122	105.26	0.0308	13.92		5,800,000	
06/19/02	35	34	153	54.18	0.0159	0.00			
07/17/02	19	28	184	35.71	0.0105	0.00			
08/15/02	21	29	213	38.11	0.0112	0.00			
09/18/02	22	34	244	34.06	0.0100	4.50	2696.08	2,200,000	2,200,000
10/16/02	22	28	275	41.35	0.0121	14.59	3273.81	2,200,000	2,200,000
11/14/02	67	29	304	121.60	0.0356	23.86	9626.44	6,700,000	6,700,000
12/17/02	118	33	335	188.20	0.0551	33.95	14898.99	11,800,000	11,800,000
01/20/03	151	34	368	233.75	0.0685	44.85	18504.90	15,100,000	15,100,000
02/21/03	167	32	401	274.67	0.0805	45.57	21744.79	16,700,000	16,700,000
03/20/03	117	27	431	228.07	0.0668	35.39	18055.56	11,700,000	11,700,000
04/18/03	67	29	459	121.60	0.0356	25.73	9626.44	6,700,000	6,700,000
05/19/03	51	31	489	86.59	0.0254	15.37	6854.84	5,100,000	5,100,000
06/18/03	29	30	519	50.88	0.0149	0.00			
07/18/03	23	30	549	40.35	0.0118	0.00			
08/18/03	19	31	580	32.26	0.0095	0.00			
09/17/03	23	30	610	40.35	0.0118	2.54		2,300,000	
10/16/03	22	29	640	39.93	0.0117	12.68		2,200,000	
11/14/03	56	29	669	101.63	0.0298	22.65		5,600,000	
12/17/03	110	33	700	175.44	0.0514	33.31		11,000,000	
						UA =	**475.898**	**150,100,000**	**78,200,000**
							-1193.783		

Table B.10b. Electricity data for Home A-10 (1-1/2 story).

Reading Date	kWh	cycle days	day	Btu/sqft-day	kWh/sqft-day	kWh (CDD)	kWh (CDD)
01/17/02	1136	30	2	68.02	0.0199		
02/18/02	838	32	33	47.04	0.0138		
03/19/02	720	29	64	44.60	0.0131		
04/17/02	736	29	93	45.59	0.0134		
05/16/02	877	29	122	54.32	0.0159		
06/19/02	1014	34	153	53.57	0.0157	1014	
07/17/02	1258	28	184	80.71	0.0236	1258	
08/15/02	1304	29	213	80.77	0.0237	1304	
09/18/02	1156	34	244	61.07	0.0179		
10/16/02	781	28	275	50.10	0.0147		
11/14/02	887	29	304	54.94	0.0161		
12/17/02	968	33	335	52.69	0.0154		
01/20/03	1038	34	368	54.84	0.0161		
02/21/03	819	32	401	45.97	0.0135		
03/20/03	705	27	431	46.90	0.0137		
04/18/03	770	29	459	47.69	0.0140		
05/19/03	767	31	489	44.44	0.0130		
06/18/03	896	30	519	53.65	0.0157	896	896
07/18/03	1211	30	549	72.51	0.0212	1211	1211
08/18/03	1692	31	580	98.04	0.0287	1692	1692
09/17/03	1509	30	610	90.35	0.0265		
10/16/03	948	29	640	58.72	0.0172		
11/14/03	780	29	669	48.31	0.0142		
12/17/03	990	33	700	53.89	0.0158		
						7375	**3799**

Table B.11a. Natural gas data for Home B-1 (ranch).

Reading Date	Therms	cycle days	day	Btu/sqft-day	kWh/sqft-day	HDD/day	Btu/h	Btu (HDD)	Btu (HDD)
01/28/02	108	30	13	152.54	0.0447	45.19		10,800,000	
02/27/02	99	30	43	139.83	0.0410	36.34		9,900,000	
03/28/02	103	29	73	150.50	0.0441	27.63		10,300,000	
04/26/02	34	29	102	49.68	0.0146	19.07		3,400,000	
05/28/02	32	32	132	42.37	0.0124	10.06		3,200,000	
06/26/02	23	29	163	33.61	0.0098	0.00			
07/26/02	26	30	192	36.72	0.0108	0.00			
08/24/02	36	29	222	52.60	0.0154	0.00			
09/25/02	8	32	252	10.59	0.0031	0.00			
10/23/02	29	28	282	43.89	0.0129	16.49	4315.48	2,900,000	2,900,000
11/25/02	51	33	313	65.49	0.0192	25.71	6439.39	5,100,000	5,100,000
12/30/02	108	35	347	130.75	0.0383	36.00	12857.14	10,800,000	10,800,000
01/28/03	124	29	379	181.18	0.0531	45.67	17816.09	12,400,000	12,400,000
02/26/03	91	29	408	132.96	0.0390	38.50	13074.71	9,100,000	9,100,000
03/28/03	95	30	437	134.18	0.0393	28.85	13194.44	9,500,000	9,500,000
04/28/03	42	31	468	57.41	0.0168	18.87	5645.16	4,200,000	4,200,000
05/28/03	14	30	498	19.77	0.0058	8.89	1944.44	1,400,000	1,400,000
06/27/03	13	30	528	18.36	0.0054	0.00			
07/28/03	23	31	559	31.44	0.0092	0.00			
08/26/03	3	29	589	4.38	0.0013	0.00			
09/25/03	11	30	618	15.54	0.0046	4.34		1,100,000	
10/24/03	15	29	648	21.92	0.0064	13.06		1,500,000	
11/22/03	31	29	677	45.30	0.0133	21.64		3,100,000	
12/27/03	97	35	709	117.43	0.0344	31.10		9,700,000	
						UA =	**430.042**	**108,400,000**	**55,400,000**
							-2360.991		

Table B.11b. Electricity data for Home B-1 (ranch).

Reading Date	kWh	cycle days	day	Btu/sqft-day	kWh/sqft-day	kWh (CDD)	kWh (CDD)
02/04/02	575	30	20	27.72	0.0081		
03/06/02	627	30	50	30.23	0.0089		
04/08/02	881	33	82	38.61	0.0113		
05/06/02	548	28	112	28.30	0.0083		
06/04/02	488	29	141	24.34	0.0071		
07/08/02	1006	34	172	42.79	0.0125	1006	
08/05/02	879	28	203	45.40	0.0133	879	
09/03/02	628	29	232	31.32	0.0092	628	
10/02/02	510	29	261	25.43	0.0075		
11/04/02	592	33	292	25.94	0.0076		
12/03/02	505	29	323	25.18	0.0074		
01/06/03	672	34	354	28.58	0.0084		
02/04/03	581	29	386	28.97	0.0085		
03/10/03	698	34	417	29.69	0.0087		
04/07/03	505	28	448	26.08	0.0076		
05/05/03	374	28	476	19.32	0.0057		
06/04/03	427	30	505	20.58	0.0060		
07/07/03	561	33	537	24.58	0.0072	561	561
08/04/03	542	28	567	27.99	0.0082	542	542
09/02/03	713	29	596	35.56	0.0104	713	713
10/06/03	507	34	627	21.56	0.0063		
11/03/03	477	28	658	24.64	0.0072		
12/04/03	538	31	688	25.10	0.0074		
01/06/04	610	33	720	26.73	0.0078		
						4329	**1816**

Table B.12a. Natural gas data for Home B-2 (1-1/2 story).

Reading Date	Therms	cycle days	day	Btu/sqft-day	kWh/sqft-day	HDD/day	Btu/h	Btu (HDD)	Btu (HDD)
01/29/02	192	30	14	277.54	0.0813	44.90		19,200,000	
03/01/02	168	31	45	235.01	0.0689	35.89		16,800,000	
03/29/02	140	28	74	216.83	0.0635	27.18		14,000,000	
04/30/02	78	32	104	105.70	0.0310	18.33		7,800,000	
05/29/02	31	29	135	46.36	0.0136	9.32		3,100,000	
06/28/02	27	30	164	39.03	0.0114	0.00			
07/29/02	25	31	195	34.97	0.0102	0.00			
08/26/02	29	28	224	44.91	0.0132	0.00			
09/26/02	15	31	254	20.98	0.0061	0.00			
10/25/02	50	29	284	74.77	0.0219	16.94	7183.91	5,000,000	5,000,000
11/26/02	192	32	314	260.19	0.0762	26.17	25000.00	19,200,000	19,200,000
12/31/02	192	35	348	237.89	0.0697	36.30	22857.14	19,200,000	19,200,000
01/29/03	208	29	380	311.03	0.0911	45.98	29885.06	20,800,000	20,800,000
02/27/03	183	29	409	273.65	0.0802	38.18	26293.10	18,300,000	18,300,000
03/31/03	135	32	439	182.95	0.0536	28.20	17578.13	13,500,000	13,500,000
04/29/03	58	29	470	86.73	0.0254	18.22	8333.33	5,800,000	5,800,000
05/29/03	35	30	499	50.59	0.0148	8.56	4861.11	3,500,000	3,500,000
06/27/03	23	29	529	34.39	0.0101	0.00			
07/29/03	31	32	559	42.01	0.0123	0.00			
08/27/03	13	29	590	19.44	0.0057	0.00			
09/26/03	22	30	619	31.80	0.0093	4.64		2,200,000	
10/25/03	37	29	649	55.33	0.0162	13.36		3,700,000	
11/25/03	116	31	679	162.27	0.0475	22.23		11,600,000	
12/30/03	188	35	712	232.93	0.0682	31.99		18,800,000	
						UA =	**727.461**	**202,500,000**	**105,300,000**
							-2123.300		

Table B.12b. Electricity data for Home B-2 (1-1/2 story).

Reading Date	kWh	cycle days	day	Btu/sqft-day	kWh/sqft-day	kWh (CDD)	kWh (CDD)
01/18/02	889	30	3	43.86	0.0129		
02/19/02	998	32	34	46.16	0.0135		
03/19/02	668	28	64	35.31	0.0103		
04/15/02	754	27	92	41.33	0.0121		
05/21/02	739	36	123	30.38	0.0089		
06/22/02	1187	32	157	54.90	0.0161		
07/20/02	1432	28	187	75.69	0.0222	1432	
08/20/02	1329	31	217	63.45	0.0186	1329	
09/20/02	1028	31	248	49.08	0.0144	1028	
10/21/02	697	31	279	33.28	0.0098		
11/20/02	609	30	309	30.04	0.0088		
12/18/02	806	28	338	42.60	0.0125		
01/15/03	930	28	366	49.16	0.0144		
02/17/03	1235	33	397	55.39	0.0162		
03/18/03	777	29	428	39.65	0.0116		
05/20/03	706	63	474	16.59	0.0049		
06/18/03	788	29	520	40.22	0.0118		
07/15/03	1312	27	548	71.92	0.0211	1312	1312
08/18/03	1758	34	578	76.53	0.0224	1758	1758
09/19/03	1591	32	611	73.59	0.0216	1591	1591
10/23/03	1039	34	644	45.23	0.0133		
11/21/03	1135	29	676	57.93	0.0170		
12/20/03	1220	29	705	62.26	0.0182		
						8450	**4661**

Table B.13a. Natural gas data for Home B-3 (ranch).

Reading Date	Therms	cycle days	day	Btu/sqft-day	kWh/sqft-day	HDD/day	Btu/h	Btu (HDD)	Btu (HDD)
01/29/02	193	30	14	384.08	0.1125	44.90		19,300,000	
02/28/02	99	30	44	197.01	0.0577	36.04		9,900,000	
03/28/02	129	28	73	275.05	0.0806	27.48		12,900,000	
04/29/02	76	32	103	141.79	0.0415	18.62		7,600,000	
05/29/02	38	30	134	75.62	0.0222	9.47		3,800,000	
06/27/02	21	29	164	43.23	0.0127	0.00			
07/29/02	23	32	194	42.91	0.0126	0.00			
08/27/02	21	29	225	43.23	0.0127	0.00			
09/26/02	24	30	254	47.76	0.0140	0.00			
10/25/02	41	29	284	84.41	0.0247	16.94	5890.80	4,100,000	4,100,000
11/25/02	93	31	314	179.10	0.0525	26.02	12500.00	9,300,000	9,300,000
12/30/02	154	35	347	262.69	0.0770	36.00	18333.33	15,400,000	15,400,000
01/30/03	178	31	380	342.80	0.1004	45.98	23924.73	17,800,000	17,800,000
03/03/03	172	32	411	320.90	0.0940	37.36	22395.83	17,200,000	17,200,000
04/01/03	90	29	442	185.28	0.0543	27.38	12931.03	9,000,000	9,000,000
04/29/03	52	28	470	110.87	0.0325	18.05	7738.10	5,200,000	5,200,000
05/29/03	33	30	499	65.67	0.0192	8.56	4583.33	3,300,000	3,300,000
06/26/03	20	28	528	42.64	0.0125	0.00			
07/29/03	22	33	559	39.80	0.0117	0.00			
08/27/03	19	29	590	39.11	0.0115	0.00			
09/26/03	19	30	619	37.81	0.0111	4.64		1,900,000	
10/27/03	42	31	650	80.89	0.0237	13.66		4,200,000	
11/25/03	70	29	680	144.11	0.0422	22.53		7,000,000	
12/30/03	127	35	712	216.63	0.0635	31.99		12,700,000	
						UA =	**585.421**	**160,600,000**	**81,300,000**
							-2290.104		

Table B.13b. Electricity data for Home B-3 (ranch).

Reading Date	kWh	cycle days	day	Btu/sqft-day	kWh/sqft-day	kWh (CDD)	kWh (CDD)
01/19/02	945	30	4	64.18	0.0188		
02/19/02	634	31	35	41.67	0.0122		
03/20/02	583	29	65	40.96	0.0120		
04/18/02	519	29	94	36.47	0.0107		
05/21/02	574	33	125	35.44	0.0104		
06/22/02	697	32	157	44.38	0.0130		
07/20/02	949	28	187	69.06	0.0202	949	
08/20/02	995	31	217	65.40	0.0192	995	
09/20/02	864	31	248	56.79	0.0166	864	
10/21/02	533	31	279	35.03	0.0103		
11/20/02	574	30	309	38.99	0.0114		
12/19/02	570	29	339	40.05	0.0117		
01/17/03	677	29	368	47.57	0.0139		
02/17/03	691	31	398	45.42	0.0133		
03/18/03	513	29	428	36.04	0.0106		
04/17/03	468	30	457	31.79	0.0093		
05/21/03	446	34	489	26.73	0.0078		
06/19/03	336	29	521	23.61	0.0069		
07/16/03	684	27	549	51.62	0.0151	684	684
08/18/03	720	33	579	44.46	0.0130	720	720
09/22/03	783	35	613	45.58	0.0134	783	783
10/22/03	507	30	645	34.44	0.0101		
11/20/03	526	29	675	36.96	0.0108		
12/20/03	496	30	704	33.69	0.0099		
						4995	**2187**

Table B.14a. Natural gas data for Home B-4 (2-story).

Reading Date	Therms	Cycle days	day	Btu/sqft-day	kWh/sqft-day	HDD/day	Btu/h	Btu (HDD)	Btu (HDD)
05/14/02	40	30	119	71.00	0.0208	13.90		4,000,000	
06/17/02	25	34	151	39.15	0.0115	4.45		2,500,000	
07/15/02	9	28	182	17.12	0.0050	0.00			
08/14/02	12	30	211	21.30	0.0062	0.00			
09/12/02	15	29	241	27.54	0.0081	0.00			
10/14/02	18	32	271	29.95	0.0088	0.00			
11/13/02	75	30	302	133.12	0.0390	22.54	10416.67	7,500,000	7,500,000
12/16/02	134	33	334	216.22	0.0634	32.06	16919.19	13,400,000	13,400,000
01/16/03	152	31	366	261.09	0.0765	41.74	20430.11	15,200,000	15,200,000
02/14/03	174	29	396	319.49	0.0936	42.43	25000.00	17,400,000	17,400,000
03/18/03	149	32	426	247.94	0.0726	32.45	19401.04	14,900,000	14,900,000
04/17/03	66	30	457	117.15	0.0343	22.31	9166.67	6,600,000	6,600,000
05/16/03	40	29	487	73.45	0.0215	12.65	5747.13	4,000,000	4,000,000
06/17/03	29	32	517	48.26	0.0141	0.00			
07/16/03	19	29	548	34.89	0.0102	0.00			
08/14/03	18	29	577	33.05	0.0097	0.00			
09/15/03	22	32	607	36.61	0.0107	0.00			
10/14/03	19	29	638	34.89	0.0102	10.11		1,900,000	
11/12/03	68	29	667	124.86	0.0366	18.68		6,800,000	
12/15/03	134	33	698	216.22	0.0634	27.85		13,400,000	
01/15/04	157	31	730	269.68	0.0790	37.31		15,700,000	
						UA =	**619.181**	**123,300,000**	**79,000,000**
							-2940.696		

Table B.14b. Electricity data for Home B-4 (2-story).

Reading Date	kWh	cycle days	day	Btu/sqft-day	kWh/sqft-day	kWh (CDD)	kWh (CDD)
05/14/02	104	30	119	6.30	0.0018		
06/14/02	2111	31	150	123.76	0.0363		
07/15/02	2603	31	181	152.60	0.0447	2603	
08/15/02	2292	31	212	134.37	0.0394	2292	
09/13/02	2642	29	242	165.57	0.0485	2642	
10/14/02	2059	31	272	120.71	0.0354		
11/13/02	2090	30	302	126.61	0.0371		
12/12/02	2004	29	332	125.58	0.0368		
01/15/03	1972	34	363	105.41	0.0309		
02/12/03	1953	28	394	126.76	0.0371		
03/13/03	2252	29	423	141.13	0.0413		
04/11/03	1721	29	452	107.85	0.0316		
05/14/03	1546	33	483	85.14	0.0249		
06/12/03	1933	29	514	121.14	0.0355		
07/16/03	2568	34	545	137.26	0.0402	2568	2568
08/15/03	2546	30	577	154.23	0.0452	2546	2546
09/12/03	2738	28	606	177.71	0.0521	2738	2738
10/14/03	2191	32	636	124.43	0.0365		
11/12/03	1656	29	667	103.78	0.0304		
12/12/03	1617	30	696	97.95	0.0287		
01/16/04	2211	35	729	114.80	0.0336		
						15389	**7852**

Table B.15a. Natural gas data for Home B-5 (2-story).

Reading Date	Therms	cycle days	day	Btu/sqft-day	kWh/sqft-day	HDD/day	Btu/h	Btu (HDD)	Btu (HDD)
01/30/02	67	18	21	209.70	0.0614	42.83		6,700,000	
03/05/02	145	34	47	240.27	0.0704	35.15		14,500,000	
04/10/02	107	36	82	167.45	0.0491	24.82		10,700,000	
05/13/02	37	33	117	63.17	0.0185	14.64		3,700,000	
06/11/02	25	29	148	48.57	0.0142	5.49		2,500,000	
07/10/02	17	29	177	33.03	0.0097	0.00			
08/12/02	13	33	208	22.19	0.0065	0.00			
09/10/02	13	29	239	25.25	0.0074	0.00			
10/10/02	19	30	268	35.68	0.0105	0.00			
11/07/02	59	28	297	118.71	0.0348	21.03	8779.76	5,900,000	5,900,000
12/11/02	104	34	328	172.33	0.0505	30.40	12745.10	10,400,000	10,400,000
01/14/03	110	34	362	182.27	0.0534	40.68	13480.39	11,000,000	11,000,000
02/12/03	173	29	394	336.09	0.0985	43.08	24856.32	17,300,000	17,300,000
03/17/03	143	33	425	244.13	0.0715	32.94	18055.56	14,300,000	14,300,000
04/15/03	62	29	456	120.45	0.0353	22.80	8908.05	6,200,000	6,200,000
05/13/03	34	28	484	68.41	0.0200	13.47	5059.52	3,400,000	3,400,000
06/12/03	22	30	513	41.31	0.0121	3.98	3055.56	2,200,000	2,200,000
07/15/03	16	33	545	27.32	0.0080	0.00			
08/13/03	11	29	576	21.37	0.0063	0.00			
09/11/03	10	29	605	19.43	0.0057	0.00			
10/09/03	22	28	633	44.27	0.0130	8.78		2,200,000	
11/10/03	50	32	663	88.03	0.0258	17.65		5,000,000	
12/11/03	89	31	695	161.74	0.0474	26.96		8,900,000	
01/14/04	134	34	727	222.04	0.0651	36.57		13,400,000	
						UA =	**476.590**	**138,300,000**	**70,700,000**
							-546.959		

Table B.15b. Electricity data for Home B-5 (2-story).

Reading Date	kWh	cycle days	day	Btu/sqft-day	kWh/sqft-day	kWh (CDD)	kWh (CDD)
02/13/02	973	30	29	62.36	0.0183		
03/13/02	886	28	58	60.84	0.0178		
04/15/02	981	33	89	57.16	0.0167		
05/14/02	748	29	120	49.59	0.0145		
06/14/02	717	31	150	44.47	0.0130		
07/15/02	1192	31	181	73.93	0.0217	1192	
08/15/02	794	31	212	49.25	0.0144	794	
09/13/02	912	29	242	60.47	0.0177	912	
10/14/02	721	31	272	44.72	0.0131		
11/13/02	924	30	302	59.22	0.0174		
12/12/02	888	29	332	58.88	0.0173		
01/15/03	855	34	363	48.35	0.0142		
02/12/03	944	28	394	64.83	0.0190		
03/13/03	898	29	423	59.54	0.0174		
04/11/03	853	29	452	56.56	0.0166		
05/14/03	689	33	483	40.15	0.0118		
06/12/03	700	29	514	46.41	0.0136		
07/16/03	1087	34	545	61.47	0.0180	1087	1087
08/15/03	747	30	577	47.88	0.0140	747	747
09/12/03	757	28	606	51.98	0.0152	757	757
10/14/03	675	32	636	40.56	0.0119		
11/12/03	708	29	667	46.94	0.0138		
12/12/03	790	30	696	50.63	0.0148		
01/16/04	1014	35	729	55.71	0.0163		
						5489	**2591**

Table B.16a. Natural gas data for Home B-6 (ranch).

Reading Date	Therms	cycle days	day	Btu/sqft-day	kWh/sqft-day	HDD/day	Btu/h	Btu (HDD)	Btu (HDD)
01/18/02	105	30	3	168.92	0.0495	48.14		10,500,000	
02/21/02	105	34	35	149.05	0.0437	38.70		10,500,000	
03/20/02	92	27	66	164.45	0.0482	29.69		9,200,000	
04/22/02	69	33	96	100.91	0.0296	20.84		6,900,000	
05/17/02	37	25	125	71.43	0.0209	12.28		3,700,000	
06/18/02	25	32	153	37.71	0.0110	0.00			
07/18/02	21	30	184	33.78	0.0099	0.00			
08/16/02	19	29	214	31.62	0.0093	0.00			
09/19/02	20	34	245	28.39	0.0083	0.00			
10/16/02	19	27	276	33.96	0.0100	14.53	2932.10	1,900,000	1,900,000
11/15/02	67	30	304	107.79	0.0316	23.14	9305.56	6,700,000	6,700,000
12/17/02	89	32	335	134.23	0.0393	32.52	11588.54	8,900,000	8,900,000
01/20/03	116	34	368	164.66	0.0482	42.50	14215.69	11,600,000	11,600,000
02/19/03	127	30	400	204.31	0.0599	40.96	17638.89	12,700,000	12,700,000
03/20/03	99	29	430	164.76	0.0483	31.30	14224.14	9,900,000	9,900,000
04/18/03	65	29	459	108.17	0.0317	21.82	9339.08	6,500,000	6,500,000
05/19/03	39	31	489	60.72	0.0178	12.00	5241.94	3,900,000	3,900,000
06/19/03	23	31	520	35.81	0.0105	0.00			
07/18/03	22	29	550	36.61	0.0107	0.00			
08/18/03	20	31	580	31.14	0.0091	0.00			
09/17/03	19	30	610	30.57	0.0090	1.98		1,900,000	
10/16/03	18	29	640	29.96	0.0088	10.70		1,800,000	
11/14/03	51	29	669	84.88	0.0249	19.27		5,100,000	
12/19/03	109	35	701	150.30	0.0440	28.74		10,900,000	
						UA =	**400.935**	**122,600,000**	**62,100,000**
							-402.927		

Table B.16b. Electricity data for Home B-6 (ranch).

Reading Date	kWh	cycle days	day	Btu/sqft-day	kWh/sqft-day	kWh (CDD)	kWh (CDD)
01/31/02	1537	30	16	84.39	0.0247		
02/28/02	1584	28	45	93.18	0.0273		
03/31/02	1092	31	75	58.02	0.0170		
04/30/02	1310	30	105	71.93	0.0211		
05/31/02	1033	31	136	54.89	0.0161		
06/30/02	1552	30	166	85.21	0.0250	1552	
07/31/02	2348	31	197	124.76	0.0366	2348	
08/31/02	1783	31	228	94.74	0.0278	1783	
09/30/02	1504	30	258	82.58	0.0242		
10/31/02	1320	31	289	70.14	0.0206		
11/30/02	1225	30	319	67.26	0.0197		
12/31/02	1712	31	350	90.97	0.0267		
01/31/03	1475	31	381	78.37	0.0230		
02/28/03	1519	28	410	89.36	0.0262		
03/31/03	1320	31	440	70.14	0.0206		
04/30/03	919	30	470	50.46	0.0148		
05/31/03	1007	31	501	53.51	0.0157		
06/30/03	1274	30	531	69.95	0.0205	1274	1274
07/31/03	1604	31	562	85.23	0.0250	1604	1604
08/31/03	1585	31	593	84.22	0.0247	1585	1585
09/30/03	923	30	623	50.68	0.0148		
10/31/03	755	31	654	40.12	0.0118		
11/30/03	664	30	684	36.46	0.0107		
12/31/03	1449	31	715	76.99	0.0226		
						10146	**4463**

Table B.17a. Natural gas data for Home B-7 (split-level).

Reading Date	Therms	cycle days	day	Btu/sqft-day	kWh/sqft-day	HDD/day	Btu/h	Btu (HDD)	Btu (HDD)
01/17/02	110	30	2	357.72	0.1048	48.4384		11,000,000	
02/15/02	90	29	32	302.78	0.0887	39.73		9,000,000	
03/19/02	94	32	62	286.59	0.0840	30.7264		9,400,000	
04/17/02	54	29	93	181.67	0.0532	21.7228		5,400,000	
05/15/02	26	28	121	90.59	0.0265	13.3096		2,600,000	
06/14/02	13	30	150	42.28	0.0124	4.7488		1,300,000	
07/16/02	12	32	181	36.59	0.0107	0			
08/15/02	9	30	212	29.27	0.0086	0			
09/13/02	10	29	242	33.64	0.0099	0			
10/14/02	16	31	272	50.35	0.0148	0			1,600,000
11/13/02	62	30	302	201.63	0.0591	22.5392	8611.11	6,200,000	6,200,000
12/13/02	80	30	332	260.16	0.0762	31.6112	11111.11	8,000,000	8,000,000
01/16/03	107	34	364	307.03	0.0900	41.288	13112.75	10,700,000	10,700,000
02/17/03	130	32	397	396.34	0.1161	41.9384	16927.08	13,000,000	13,000,000
03/18/03	92	29	428	309.50	0.0907	31.9588	13218.39	9,200,000	9,200,000
04/16/03	43	29	457	144.66	0.0424	22.47	6178.16	4,300,000	4,300,000
05/15/03	21	29	486	70.65	0.0207	12.9812	3017.24	2,100,000	2,100,000
06/18/03	18	34	517	51.65	0.0151	0			
07/16/03	12	28	548	41.81	0.0123	0			
08/14/03	10	29	577	33.64	0.0099	0			
09/15/03	13	32	607	39.63	0.0116	0			
10/14/03	15	29	638	50.46	0.0148	10.10795		1,500,000	
11/12/03	49	29	667	164.84	0.0483	18.68325		4,900,000	
12/15/03	91	33	698	269.03	0.0788	27.84995		9,100,000	
						UA =	**423.320**	**107,700,000**	**55,100,000**
							-2073.495		

Table B.17b. Electricity data for Home B-7 (split-level).

Reading Date	kWh	cycle days	day	Btu/sqft-day	kWh/sqft-day	kWh (CDD)	kWh (CDD)
01/17/02	556	30	2	61.71	0.0181		
02/15/02	425	29	32	48.80	0.0143		
03/19/02	462	32	62	48.07	0.0141		
04/17/02	428	29	93	49.14	0.0144		
05/15/02	374	28	121	44.48	0.0130		
06/14/02	637	30	150	70.70	0.0207		
07/16/02	1104	32	181	114.88	0.0337	1104	
08/15/02	1050	30	212	116.54	0.0341	1050	
09/13/02	823	29	242	94.50	0.0277	823	
10/14/02	533	31	272	57.25	0.0168		
11/13/02	459	30	302	50.94	0.0149		
12/13/02	475	30	332	52.72	0.0154		
01/16/03	612	34	364	59.94	0.0176		
02/17/03	513	32	397	53.38	0.0156		
03/18/03	452	29	428	51.90	0.0152		
04/16/03	475	29	457	54.54	0.0160		
05/15/03	408	29	486	46.85	0.0137		
06/18/03	682	34	517	66.79	0.0196		
07/16/03	921	28	548	109.52	0.0321	921	921
08/14/03	938	29	577	107.70	0.0316	938	938
09/15/03	1120	32	607	116.54	0.0341	1120	1120
10/14/03	552	29	638	63.38	0.0186		
11/12/03	509	29	667	58.44	0.0171		
12/15/03	502	33	698	50.65	0.0148		
						5956	**2979**

Table B.18a. Natural gas data for Home B-8 (ranch).

Reading Date	Therms	cycle days	day	Btu/sqft-day	kWh/sqft-day	HDD/day	Btu/h	Btu (HDD)	Btu (HDD)
01/18/02	170	30	3	259.94	0.0762	48.14		17,000,000	
02/21/02	169	34	35	228.01	0.0668	38.70		16,900,000	
03/20/02	141	27	66	239.55	0.0702	29.69		14,100,000	
04/22/02	102	33	96	141.78	0.0415	20.84		10,200,000	
05/17/02	52	25	125	95.41	0.0280	12.28		5,200,000	
06/18/02	42	32	153	60.21	0.0176	0.00			
07/18/02	27	30	184	41.28	0.0121	0.00			
08/16/02	29	29	214	45.87	0.0134	0.00			
09/19/02	35	34	245	47.22	0.0138	0.00			
10/16/02	29	27	276	49.27	0.0144	14.53	4475.31	2,900,000	2,900,000
11/15/02	93	30	304	142.20	0.0417	23.14	12916.67	9,300,000	9,300,000
12/17/02	135	32	335	193.52	0.0567	32.52	17578.13	13,500,000	13,500,000
01/20/03	172	34	368	232.06	0.0680	42.50	21078.43	17,200,000	17,200,000
02/19/03	177	30	400	270.64	0.0793	40.96	24583.33	17,700,000	17,700,000
03/20/03	141	29	430	223.03	0.0653	31.30	20258.62	14,100,000	14,100,000
04/18/03	69	29	459	109.14	0.0320	21.82	9913.79	6,900,000	6,900,000
05/19/03	46	31	489	68.07	0.0199	12.00	6182.80	4,600,000	4,600,000
06/19/03	33	31	520	48.83	0.0143	0.00			
07/18/03	26	29	550	41.13	0.0120	0.00			
08/18/03	29	31	580	42.91	0.0126	0.00			
09/17/03	26	30	610	39.76	0.0116	1.98		2,600,000	
10/16/03	34	29	640	53.78	0.0158	10.70		3,400,000	
11/14/03	70	29	669	110.72	0.0324	19.27		7,000,000	
12/19/03	150	35	701	196.59	0.0576	28.74		15,000,000	
						UA =	**622.743**	**177,600,000**	**86,200,000**
							-2405.682		

Table B.18b. Electricity data for Home B-8 (ranch).

Reading Date	kWh	cycle days	day	Btu/sqft-day	kWh/sqft-day	kWh (CDD)	kWh (CDD)
01/18/02	984	30	3	51.35	0.0150		
02/21/02	855	34	35	39.37	0.0115		
03/20/02	783	27	66	45.40	0.0133		
04/22/02	867	33	96	41.13	0.0121		
05/17/02	682	25	125	42.71	0.0125		
06/18/02	1327	32	153	64.92	0.0190		
07/18/02	1627	30	184	84.91	0.0249	1627	
08/16/02	1608	29	214	86.81	0.0254	1608	
09/19/02	1819	34	245	83.76	0.0245	1819	
10/16/02	813	27	276	47.14	0.0138		
11/15/02	819	30	304	42.74	0.0125		
12/17/02	967	32	335	47.31	0.0139		
01/20/03	1051	34	368	48.39	0.0142		
02/19/03	905	30	400	47.23	0.0138		
03/20/03	830	29	430	44.81	0.0131		
04/18/03	792	29	459	42.76	0.0125		
05/19/03	887	31	489	44.80	0.0131		
06/19/03	1067	31	520	53.89	0.0158		
07/18/03	1482	29	550	80.01	0.0234	1482	1482
08/18/03	1752	31	580	88.48	0.0259	1752	1752
09/17/03	1403	30	610	73.22	0.0215	1403	1403
10/16/03	891	29	640	48.10	0.0141		
11/14/03	878	29	669	47.40	0.0139		
12/19/03	1019	35	701	45.58	0.0134		
						9691	**4637**

Table B.19a. Natural gas data for Home B-9 (2-story).

Reading Date	Therms	cycle days	day	Btu/sqft-day	kWh/sqft-day	HDD/day	Btu/h	Btu (HDD)	Btu (HDD)
01/25/02	204	30	10	295.65	0.0866	46.08		20,400,000	
02/25/02	184	31	41	258.06	0.0756	37.07		18,400,000	
03/27/02	209	30	71	302.90	0.0887	28.07		20,900,000	
04/24/02	99	28	100	153.73	0.0450	19.51		9,900,000	
05/23/02	81	29	129	121.44	0.0356	11.10		8,100,000	
06/26/02	53	34	160	67.77	0.0199	0.00			
07/24/02	41	28	191	63.66	0.0187	0.00			
08/22/02	42	29	220	62.97	0.0184	0.00			
09/23/02	46	32	250	62.50	0.0183	0.00			
10/23/02	72	30	281	104.35	0.0306	16.19	10000.00	7,200,000	7,200,000
11/20/02	129	28	310	200.31	0.0587	24.96	19196.43	12,900,000	12,900,000
12/23/02	193	33	341	254.28	0.0745	34.18	24368.69	19,300,000	19,300,000
01/24/03	247	32	373	335.60	0.0983	44.01	32161.46	24,700,000	24,700,000
02/26/03	261	33	406	343.87	0.1008	39.16	32954.55	26,100,000	26,100,000
03/26/03	156	28	436	242.24	0.0710	29.18	23214.29	15,600,000	15,600,000
04/24/03	101	29	465	151.42	0.0444	19.85	14511.49	10,100,000	10,100,000
05/23/03	59	29	494	88.46	0.0259	10.36	8477.01	5,900,000	5,900,000
06/25/03	50	33	525	65.88	0.0193	0.00			
07/24/03	42	29	556	62.97	0.0184	0.00			
08/22/03	40	29	585	59.97	0.0176	0.00			
09/23/03	44	32	615	59.78	0.0175	3.45		4,400,000	
10/22/03	56	29	646	83.96	0.0246	12.47		5,600,000	
11/20/03	119	29	675	178.41	0.0523	21.05		11,900,000	
12/23/03	193	33	706	254.28	0.0745	30.22		19,300,000	
						UA =	**788.038**	**240,700,000**	**121,800,000**
							-852.644		

Table B.19b. Electricity data for Home B-9 (2-story).

Reading Date	kWh	cycle days	day	Btu/sqft-day	kWh/sqft-day	kWh (CDD)	kWh (CDD)
01/25/02	1087	30	10	53.77	0.0158		
02/25/02	1112	31	41	40.00	0.0117		
03/27/02	1142	30	71	42.44	0.0124		
04/24/02	897	28	100	35.72	0.0105		
05/23/02	873	29	129	33.56	0.0098		
06/26/02	1782	34	160	58.44	0.0171	1782	
07/24/02	2006	28	191	79.88	0.0234	2006	
08/22/02	1593	29	220	61.25	0.0179	1593	
09/23/02	1601	32	250	55.78	0.0163		
10/23/02	1021	30	281	37.95	0.0111		
11/20/02	1058	28	310	42.13	0.0123		
12/23/02	1324	33	341	44.73	0.0131		
01/24/03	1343	32	373	46.79	0.0137		
02/26/03	1316	33	406	44.46	0.0130		
03/26/03	996	28	436	39.66	0.0116		
04/24/03	889	29	465	34.18	0.0100		
05/23/03	822	29	494	31.60	0.0093		
06/25/03	1105	33	525	37.34	0.0109	1105	1105
07/24/03	1632	29	556	62.75	0.0184	1632	1632
08/22/03	1810	29	585	69.59	0.0204	1810	1810
09/23/03	1300	32	615	45.30	0.0133		
10/22/03	846	29	646	32.53	0.0095		
11/20/03	1026	29	675	39.45	0.0116		
12/23/03	1267	33	706	42.81	0.0125		
						9928	**4547**

Table B.20a. Natural gas data for Home B-10 (1-1/2 story).

Reading Date	Therms	cycle days	day	Btu/sqft-day	kWh/sqft-day	HDD/day	Btu/h	Btu (HDD)	Btu (HDD)
01/16/02	310	30	1	337.58	0.0989	48.73		31,000,000	
02/16/02	295	31	32	310.88	0.0911	39.73		29,500,000	
03/16/02	273	28	61	318.52	0.0933	31.02		27,300,000	
04/16/02	187	31	91	197.07	0.0577	22.31		18,700,000	
05/16/02	124	30	121	135.03	0.0396	13.31		12,400,000	
06/18/02	86	33	153	85.14	0.0249	0.00			
07/17/02	55	29	184	61.96	0.0182	0.00			
08/16/02	41	30	213	44.65	0.0131	0.00			
09/17/02	68	32	244	69.42	0.0203	0.00			
10/16/02	69	29	275	77.73	0.0228	14.22	9913.79	6,900,000	6,900,000
11/18/02	213	33	306	210.86	0.0618	23.60	26893.94	21,300,000	21,300,000
12/16/02	231	28	336	269.52	0.0790	32.82	34375.00	23,100,000	23,100,000
01/16/03	292	31	366	307.72	0.0902	41.74	39247.31	29,200,000	29,200,000
02/18/03	384	33	398	380.15	0.1114	41.77	48484.85	38,400,000	38,400,000
03/18/03	273	28	428	318.52	0.0933	31.80	40625.00	27,300,000	27,300,000
04/15/03	144	28	456	168.01	0.0492	22.63	21428.57	14,400,000	14,400,000
05/16/03	90	31	486	94.85	0.0278	12.98	12096.77	9,000,000	9,000,000
06/17/03	61	32	517	62.28	0.0182	0.00			
07/17/03	35	30	548	38.11	0.0112	0.00			
08/18/03	38	32	579	38.79	0.0114	0.00			
09/17/03	44	30	610	47.91	0.0140	1.98		4,400,000	
10/16/03	62	29	640	69.84	0.0205	10.70		6,200,000	
11/18/03	157	33	671	155.43	0.0455	19.87		15,700,000	
12/16/03	231	28	701	269.52	0.0790	28.88		23,100,000	
						UA =	**1190.279**	**337,900,000**	**169,600,000**
							-3832.822		

Table B.20b. Electricity data for Home B-10 (1-1/2 story).

Reading Date	kWh	cycle days	day	Btu/sqft-day	kWh/sqft-day	kWh (CDD)	kWh (CDD)
01/16/02	1401	30	1	52.07	0.0153		
02/16/02	1153	31	32	41.47	0.0122		
03/16/02	991	28	61	39.46	0.0116		
04/16/02	977	31	91	35.14	0.0103		
05/16/02	967	30	121	35.94	0.0105		
06/18/02	1966	33	153	66.43	0.0195		
07/17/02	2464	29	184	94.74	0.0278	2464	
08/16/02	2568	30	213	95.44	0.0280	2568	
09/17/02	2242	32	244	78.12	0.0229	2242	
10/16/02	1128	29	275	43.37	0.0127		
11/18/02	1313	33	306	44.36	0.0130		
12/16/02	1365	28	336	54.36	0.0159		
01/16/03	1399	31	366	50.32	0.0147		
02/18/03	1431	33	398	48.35	0.0142		
03/18/03	1131	28	428	45.04	0.0132		
04/15/03	1034	28	456	41.17	0.0121		
05/16/03	1124	31	486	40.43	0.0118		
06/17/03	1420	32	517	49.48	0.0145		
07/17/03	2061	30	548	76.60	0.0224	2061	2061
08/18/03	2503	32	579	87.21	0.0256	2503	2503
09/17/03	2004	30	610	74.48	0.0218	2004	2004
10/16/03	1088	29	640	41.83	0.0123		
11/18/03	1404	33	671	47.44	0.0139		
12/16/03	1480	28	701	58.93	0.0173		
						13842	**6568**

Table B.21a. Natural gas data for Home C-1 (2-story).

Reading Date	Therms	cycle days	day	Btu/sqft-day	kWh/sqft-day	HDD/day	Btu/h	Btu (HDD)	Btu (HDD)
02/13/02	126	30	29	147.47	0.0432	33.92		12,600,000	
03/14/02	137	29	59	165.88	0.0486	26.46		13,700,000	
04/16/02	79	33	90	84.06	0.0246	18.62		7,900,000	
05/14/02	31	28	120	38.87	0.0114	10.91		3,100,000	
06/17/02	13	34	151	13.43	0.0039	0.00			
07/15/02	7	28	182	8.78	0.0026	0.00			
08/13/02	8	29	211	9.69	0.0028	0.00			
09/16/02	8	34	242	8.26	0.0024	0.00			
10/14/02	8	28	273	10.03	0.0029	8.09	1190.48	800,000	
11/14/02	72	31	303	81.55	0.0239	17.84	9677.42	7,200,000	7,200,000
12/12/02	113	28	332	141.70	0.0415	27.59	16815.48	11,300,000	11,300,000
01/15/03	140	34	363	144.58	0.0424	37.84	17156.86	14,000,000	14,000,000
02/12/03	167	28	394	209.42	0.0614	41.19	24851.19	16,700,000	16,700,000
03/13/03	146	29	423	176.77	0.0518	31.11	20977.01	14,600,000	14,600,000
04/14/03	63	32	453	69.13	0.0203	20.33	8203.13	6,300,000	6,300,000
05/14/03	30	30	484	35.11	0.0103	9.36	4166.67	3,000,000	3,000,000
06/13/03	9	30	514	10.53	0.0031	0.00			900,000
07/16/03	8	33	546	8.51	0.0025	0.00			
08/13/03	8	28	576	10.03	0.0029	0.00			
09/12/03	8	30	605	9.36	0.0027				
10/13/03	13	31	636	14.72	0.0043	8.33		1,300,000	
11/12/03	49	30	666	57.35	0.0168	18.64		4,900,000	
12/15/03	117	33	698	124.49	0.0365	29.28		11,700,000	
01/15/04	136	31	730	154.04	0.0451	40.10		13,600,000	
						UA =	**642.613**	**142,700,000**	**74,000,000**
							-2652.169		

Table B.21b. Electricity data for Home C-1 (2-story).

Reading Date	kWh	cycle days	day	Btu/sqft-day	kWh/sqft-day	kWh (CDD)	kWh (CDD)
02/15/02	1213	30	31	48.45	0.0142		
03/15/02	1688	28	60	72.24	0.0212		
04/16/02	1287	32	90	48.20	0.0141		
05/14/02	1156	28	120	49.48	0.0145		
06/17/02	1379	34	151	48.60	0.0142		
07/15/02	1264	28	182	54.10	0.0159	1264	
08/13/02	1622	29	211	67.03	0.0196	1622	
09/16/02	1249	34	242	44.02	0.0129	1249	
10/14/02	1037	28	273	44.38	0.0130		
11/14/02	1084	31	303	41.90	0.0123		
12/12/02	1229	28	332	52.60	0.0154		
01/15/03	1562	34	363	55.05	0.0161		
02/12/03	1253	28	394	53.63	0.0157		
03/13/03	1309	29	423	54.09	0.0158		
04/14/03	1170	32	453	43.82	0.0128		
05/14/03	1044	30	484	41.70	0.0122		
06/13/03	1050	30	514	41.94	0.0123		
07/16/03	1586	33	546	57.59	0.0169	1586	1586
08/13/03	1236	28	576	52.90	0.0155	1236	1236
09/12/03	1810	30	605	72.30	0.0212	1810	1810
10/13/03	1299	31	636	50.22	0.0147		
11/12/03	1149	30	666	45.90	0.0134		
12/15/03	1408	33	698	51.13	0.0150		
01/15/04	1464	31	730	56.59	0.0166		
						8767	**4632**

Table B.22a. Natural gas data for Home C-2 (ranch).

Reading Date	Therms	cycle days	day	Btu/sqft-day	kWh/sqft-day	HDD/day	Btu/h	Btu (HDD)	Btu (HDD)
02/13/02	152	30	29	256.93	0.0753	33.92		15,200,000	
03/14/02	180	29	59	314.75	0.0922	26.46		18,000,000	
04/16/02	124	33	90	190.55	0.0558	18.62		12,400,000	
05/14/02	69	28	120	124.96	0.0366	10.91		6,900,000	
06/17/02	52	34	151	77.56	0.0227	3.07		5,200,000	
07/15/02	32	28	182	57.95	0.0170	0.00			
08/13/02	29	29	211	50.71	0.0149	0.00			
09/16/02	34	34	242	50.71	0.0149	0.00			
10/14/02	32	28	273	57.95	0.0170	0.00			
11/14/02	102	31	303	166.85	0.0489	17.84	13709.68	10,200,000	10,200,000
12/12/02	145	28	332	262.61	0.0769	27.59	21577.38	14,500,000	14,500,000
01/15/03	174	34	363	259.52	0.0760	37.84	21323.53	17,400,000	17,400,000
02/12/03	191	28	394	345.91	0.1014	41.19	28422.62	19,100,000	19,100,000
03/13/03	181	29	423	316.50	0.0927	31.11	26005.75	18,100,000	18,100,000
04/14/03	104	32	453	164.81	0.0483	20.33	13541.67	10,400,000	10,400,000
05/14/03	63	30	484	106.49	0.0312	9.36	8750.00	6,300,000	6,300,000
06/13/03	51	30	514	86.21	0.0253	0.00			
07/16/03	42	33	546	64.54	0.0189	0.00			
08/13/03	31	28	576	56.14	0.0164	0.00			
09/12/03	31	30	605	52.40	0.0154	0.00			
10/13/03	44	31	636	71.98	0.0211	8.33		4,400,000	
11/12/03	144	30	666	243.41	0.0713	18.64		14,400,000	
12/15/03	144	33	698	221.28	0.0648	29.28		14,400,000	
01/15/04	166	31	730	271.54	0.0796	40.10		16,600,000	
						UA =	**588.147**	**203,500,000**	**96,000,000**
							3480.434		

Table B.22b. Electricity data for Home C-2 (ranch).

Reading Date	kWh	cycle days	day	Btu/sqft-day	kWh/sqft-day	kWh (CDD)	kWh (CDD)
02/13/02	780	30	29	45.00	0.0132		
03/14/02	961	29	59	57.35	0.0168		
04/16/02	754	33	90	39.54	0.0116		
05/14/02	749	28	120	46.30	0.0136		
06/17/02	1278	34	151	65.05	0.0191		
07/15/02	1521	28	182	94.01	0.0275	1521	
08/13/02	1259	29	211	75.14	0.0220	1259	
09/16/02	1277	34	242	65.00	0.0190	1277	
10/14/02	771	28	273	47.66	0.0140		
11/14/02	878	31	303	49.02	0.0144		
12/12/02	895	28	332	55.32	0.0162		
01/15/03	1054	34	363	53.65	0.0157		
02/12/03	847	28	394	52.35	0.0153		
03/13/03	888	29	423	53.00	0.0155		
04/14/03	829	32	453	44.84	0.0131		
05/14/03	683	30	484	39.40	0.0115		
06/13/03	825	30	514	47.59	0.0139		
07/16/03	1369	33	546	71.80	0.0210	1369	1369
08/13/03	1337	28	576	82.64	0.0242	1337	1337
09/12/03	1480	30	605	85.38	0.0250	1480	1480
10/13/03	951	31	636	53.09	0.0156		
11/12/03	871	30	666	50.25	0.0147		
12/15/03	988	33	698	51.82	0.0152		
01/15/04	944	31	730	52.70	0.0154		
						8243	**4186**

Table B.23a. Natural gas data for Home C-3 (ranch).

Reading Date	Therms	cycle days	day	Btu/sqft-day	kWh/sqft-day	HDD/day	Btu/h	Btu (HDD)	Btu (HDD)
01/29/02	165	30	14	392.86	0.1151	37.72		16,500,000	
02/27/02	128	29	44	315.27	0.0924	30.26		12,800,000	
03/28/02	129	29	73	317.73	0.0931	22.92		12,900,000	
04/30/02	95	33	104	205.63	0.0602	15.08		9,500,000	
05/28/02	60	28	134	153.06	0.0448	7.37		6,000,000	
06/27/02	51	30	163	121.43	0.0356	0.00			
07/29/02	45	32	194	100.45	0.0294	0.00			
08/27/02	43	29	225	105.91	0.0310	0.00			
09/25/02	45	29	254	110.84	0.0325	0.00			
10/25/02	60	30	283	142.86	0.0419	11.39	8333.33	6,000,000	6,000,000
11/25/02	101	31	314	232.72	0.0682	21.48	13575.27	10,100,000	10,100,000
12/30/02	158	35	347	322.45	0.0945	32.39	18809.52	15,800,000	15,800,000
01/29/03	178	30	379	423.81	0.1242	43.13	24722.22	17,800,000	17,800,000
03/03/03	182	33	411	393.94	0.1154	35.36	22979.80	18,200,000	18,200,000
03/28/03	98	25	440	280.00	0.0820	25.10	16333.33	9,800,000	9,800,000
04/29/03	92	32	468	205.36	0.0602	15.02	11979.17	9,200,000	9,200,000
05/29/03	59	30	499	140.48	0.0412	4.06	8194.44	5,900,000	5,900,000
06/27/03	51	29	529	125.62	0.0368	0.00			
07/29/03	44	32	559	98.21	0.0288	0.00			
08/27/03	36	29	590	88.67	0.0260	0.00			
09/26/03	44	30	619	104.76	0.0307	2.75		4,400,000	
10/27/03	57	31	650	131.34	0.0385	13.06		5,700,000	
11/25/03	78	29	680	192.12	0.0563	23.20		7,800,000	
12/30/03	154	35	712	314.29	0.0921	34.02		15,400,000	
						UA =	**466.047**	**183,800,000**	**92,800,000**
							4668.106		

Table B.23b. Electricity data for Home C-3 (ranch).

Reading Date	kWh	cycle days	day	Btu/sqft-day	kWh/sqft-day	kWh (CDD)	kWh (CDD)
01/31/02	1055	30	16	85.73	0.0251		
02/28/02	1045	28	45	90.98	0.0267		
03/28/02	944	28	73	82.19	0.0241		
04/30/02	959	33	104	70.84	0.0208		
05/28/02	802	28	134	69.83	0.0205		
06/27/02	1082	30	163	87.92	0.0258	1082	1082
07/29/02	1269	32	194	96.68	0.0283	1269	1269
08/27/02	1097	29	225	92.22	0.0270	1097	1097
09/25/02	802	29	254	67.42	0.0198		
10/25/02	792	30	283	64.36	0.0189		
11/25/02	927	31	314	72.90	0.0214		
12/30/02	1066	35	347	74.25	0.0218		
01/29/03	977	30	379	79.39	0.0233		
03/03/03	1030	33	411	76.09	0.0223		
03/28/03	744	25	440	72.55	0.0213		
04/29/03	967	32	468	73.67	0.0216		
05/29/03	828	30	499	67.28	0.0197		
06/27/03	840	29	529	70.61	0.0207	840	840
07/29/03	1196	32	559	91.11	0.0267	1196	1196
08/27/03	978	29	590	82.21	0.0241	978	978
09/26/03	1058	30	619	85.97	0.0252		
10/27/03	1163	31	650	91.46	0.0268		
11/25/03	1109	29	680	93.23	0.0273		
12/30/03	1330	35	712	92.64	0.0271		
						6462	**6462**

Table B.24a. Natural gas data for Home C-4 (ranch).

Reading Date	Therms	cycle days	day	Btu/sqft-day	kWh/sqft-day	HDD/day	Btu/h	Btu (HDD)	Btu (HDD)
02/11/02	120	30	27	231.88	0.0679	34.43		12,000,000	
03/12/02	111	29	57	221.89	0.0650	26.97		11,100,000	
04/09/02	84	28	85	173.91	0.0510	19.76		8,400,000	
05/08/02	38	29	114	75.96	0.0223	12.55		3,800,000	
06/10/02	33	33	145	57.97	0.0170	4.71		3,300,000	
07/10/02	19	30	176	36.71	0.0108	0.00			
08/07/02	17	28	205	35.20	0.0103	0.00			
09/06/02	18	30	234	34.78	0.0102	0.00			
10/08/02	21	32	265	38.04	0.0111	0.00			
11/05/02	63	28	295	130.43	0.0382	15.36	9375.00	6,300,000	6,300,000
12/10/02	117	35	327	193.79	0.0568	25.77	13928.57	11,700,000	11,700,000
01/13/03	134	34	361	228.47	0.0669	37.18	16421.57	13,400,000	13,400,000
02/12/03	160	30	393	309.18	0.0906	41.55	22222.22	16,000,000	16,000,000
03/13/03	139	29	423	277.86	0.0814	31.11	19971.26	13,900,000	13,900,000
04/11/03	70	29	452	139.93	0.0410	20.86	10057.47	7,000,000	7,000,000
05/09/03	40	28	480	82.82	0.0243	10.78	5952.38	4,000,000	4,000,000
06/11/03	28	33	511	49.19	0.0144	0.00			
07/10/03	19	29	542	37.98	0.0111	0.00			
08/11/03	20	32	572	36.23	0.0106	0.00			
09/10/03	19	30	603	36.71	0.0108	0.00			
10/09/03	29	29	633	57.97	0.0170	7.31		2,900,000	
11/10/03	63	32	663	114.13	0.0334	17.62		6,300,000	
12/09/03	90	29	694	179.91	0.0527	27.93		9,000,000	
01/12/04	149	34	725	254.05	0.0744	38.58		14,900,000	
						UA =	**493.879**	**144,000,000**	**72,300,000**
							1105.707		

Table B.24b. Electricity data for Home C-4 (ranch).

Reading Date	kWh	cycle days	day	Btu/sqft-day	kWh/sqft-day	kWh (CDD)	kWh (CDD)
02/11/02	798	30	27	52.63	0.0154		
03/12/02	740	29	57	50.49	0.0148		
04/09/02	683	28	85	48.26	0.0141		
05/08/02	619	29	114	42.23	0.0124		
06/10/02	764	33	145	45.81	0.0134		
07/10/02	978	30	176	64.50	0.0189	978	
08/07/02	833	28	205	58.86	0.0172	833	
09/06/02	829	30	234	54.67	0.0160	829	
10/08/02	761	32	265	47.05	0.0138		
11/05/02	642	28	295	45.36	0.0133		
12/10/02	878	35	327	49.63	0.0145		
01/13/03	932	34	361	54.24	0.0159		
02/12/03	774	30	393	51.05	0.0150		
03/13/03	735	29	423	50.15	0.0147		
04/11/03	599	29	452	40.87	0.0120		
05/09/03	552	28	480	39.01	0.0114		
06/11/03	614	33	511	36.81	0.0108		
07/10/03	826	29	542	56.35	0.0165	826	826
08/11/03	791	32	572	48.91	0.0143	791	791
09/10/03	777	30	603	51.24	0.0150	777	777
10/09/03	503	29	633	34.32	0.0101		
11/10/03	624	32	663	38.58	0.0113		
12/09/03	663	29	694	45.23	0.0133		
01/12/04	916	34	725	53.30	0.0156		
						5034	**2394**

Table B.25a. Natural gas data for Home C-5 (2-story).

Reading Date	Therms	cycle days	day	Btu/sqft-day	kWh/sqft-day	HDD/day	Btu/h	Btu (HDD)	Btu (HDD)
01/18/02	185	30	3	257.70	0.0755	40.50		18,500,000	
02/19/02	139	32	34	181.52	0.0532	32.66		13,900,000	
03/20/02	137	29	65	197.41	0.0578	24.95		13,700,000	
04/18/02	87	29	94	125.37	0.0367	17.61		8,700,000	
05/17/02	55	29	123	79.25	0.0232	10.28		5,500,000	
06/18/02	28	32	153	36.56	0.0107	0.00			
07/18/02	20	30	184	27.86	0.0082	0.00			
08/16/02	11	29	214	15.85	0.0046	0.00			
09/17/02	16	32	244	20.89	0.0061	0.00			
10/16/02	25	29	275	36.02	0.0106	8.58	3591.95	2,500,000	2,500,000
11/14/02	88	29	304	126.81	0.0372	18.17	12643.68	8,800,000	8,800,000
12/17/02	152	33	335	192.48	0.0564	28.42	19191.92	15,200,000	15,200,000
01/20/03	193	34	368	237.21	0.0695	39.49	23651.96	19,300,000	19,300,000
02/19/03	209	30	400	291.13	0.0853	39.07	29027.78	20,900,000	20,900,000
03/20/03	156	29	430	224.79	0.0659	28.64	22413.79	15,600,000	15,600,000
04/18/03	67	29	459	96.55	0.0283	18.38	9626.44	6,700,000	6,700,000
05/19/03	44	31	489	59.31	0.0174	7.77	5913.98	4,400,000	4,400,000
06/18/03	27	30	519	37.61	0.0110	0.00			
07/18/03	14	30	549	19.50	0.0057	0.00			
08/18/03	16	31	580	21.57	0.0063	0.00			
09/17/03	10	30	610	13.93	0.0041	0.00			
10/16/03	25	29	640	36.02	0.0106	9.68		2,500,000	
11/14/03	71	29	669	102.31	0.0300	19.48		7,100,000	
12/17/03	146	33	700	184.88	0.0542	29.96		14,600,000	
						UA =	**715.743**	**177,900,000**	**93,400,000**
							-1109.779		

Table B.25b. Electricity data for Home C-5 (2-story).

Reading Date	kWh	cycle days	day	Btu/sqft-day	kWh/sqft-day	kWh (CDD)	kWh (CDD)
01/18/02	1247	30	3	59.28	0.0174		
02/19/02	1033	32	34	46.04	0.0135		
03/20/02	898	29	65	44.16	0.0129		
04/18/02	821	29	94	40.38	0.0118		
05/17/02	811	29	123	39.89	0.0117		
06/18/02	1015	32	153	45.24	0.0133		
07/18/02	1896	30	184	90.14	0.0264	1896	
08/16/02	1225	29	214	60.25	0.0177	1225	
09/17/02	1443	32	244	64.31	0.0188	1443	
10/16/02	982	29	275	48.30	0.0142		
11/14/02	1046	29	304	51.44	0.0151		
12/17/02	1418	33	335	61.28	0.0180		
01/20/03	1337	34	368	56.08	0.0164		
02/19/03	1224	30	400	58.19	0.0170		
03/20/03	1118	29	430	54.98	0.0161		
04/18/03	900	29	459	44.26	0.0130		
05/19/03	959	31	489	44.12	0.0129		
06/18/03	1160	30	519	55.15	0.0162		
07/18/03	1379	30	549	65.56	0.0192	1379	1379
08/18/03	1446	31	580	66.53	0.0195	1446	1446
09/17/03	993	30	610	47.21	0.0138	993	993
10/16/03	771	29	640	37.92	0.0111		
11/14/03	972	29	669	47.80	0.0140		
12/17/03	1426	33	700	61.63	0.0181		
						8382	**3818**

Table B.26a. Natural gas data for Home C-6 (2-story).

Reading Date	Therms	cycle days	day	Btu/sqft-day	kWh/sqft-day	HDD/day	Btu/h	Btu (HDD)	Btu (HDD)
01/24/02	137	30	9	260.51	0.0763	38.98		13,700,000	
02/26/02	102	33	41	176.32	0.0517	31.02		10,200,000	
03/26/02	95	28	71	193.55	0.0567	23.30		9,500,000	
04/26/02	49	31	101	90.17	0.0264	15.84		4,900,000	
05/24/02	30	28	130	61.12	0.0179	8.38		3,000,000	
06/25/02	22	32	160	39.22	0.0115	0.00			
07/24/02	20	29	191	39.34	0.0115	0.00			
08/26/02	20	33	222	34.57	0.0101	0.00			
09/23/02	14	28	252	28.52	0.0084	0.00			
10/23/02	30	30	281	57.05	0.0167	10.73	4166.67	3,000,000	3,000,000
11/21/02	66	29	311	129.83	0.0380	20.48	9482.76	6,600,000	6,600,000
12/26/02	124	35	343	202.10	0.0592	31.06	14761.90	12,400,000	12,400,000
01/27/03	139	32	376	247.79	0.0726	42.14	18098.96	13,900,000	13,900,000
02/26/03	124	30	407	235.79	0.0691	36.60	17222.22	12,400,000	12,400,000
03/27/03	82	29	437	161.30	0.0473	26.16	11781.61	8,200,000	8,200,000
04/24/03	49	28	465	99.83	0.0292	16.08	7291.67	4,900,000	4,900,000
05/27/03	30	33	496	51.86	0.0152	5.29	3787.88	3,000,000	3,000,000
06/25/03	23	29	527	45.24	0.0133	0.00			
07/25/03	21	30	556	39.93	0.0117	0.00			
08/25/03	21	31	587	38.64	0.0113	0.00			
09/24/03	21	30	617	39.93	0.0117	2.07		2,100,000	
10/22/03	25	28	646	50.93	0.0149	11.88		2,500,000	
11/21/03	55	30	675	104.58	0.0306	21.68		5,500,000	
12/29/03	131	38	709	196.66	0.0576	33.17		13,100,000	
						UA =	**433.596**	**128,900,000**	**64,400,000**
							604.525		

Table B.26b. Electricity data for Home C-6 (2-story).

Reading Date	kWh	cycle days	day	Btu/sqft-day	kWh/sqft-day	kWh (CDD)	kWh (CDD)
01/22/02	755	30	7	49.00	0.0144		
02/21/02	544	30	37	35.30	0.0103		
03/21/02	513	28	66	35.67	0.0105		
04/18/02	503	28	94	34.98	0.0102		
05/21/02	509	33	125	30.03	0.0088		
06/20/02	693	30	156	44.97	0.0132	693	693
07/18/02	982	28	185	68.28	0.0200	982	982
08/19/02	1065	32	215	64.80	0.0190	1065	1065
09/19/02	774	31	247	48.61	0.0142		
10/17/02	496	28	276	34.49	0.0101		
11/19/02	577	33	307	34.04	0.0100		
12/20/02	662	31	339	41.58	0.0122		
01/24/03	812	35	372	45.17	0.0132		
02/21/03	606	28	403	42.14	0.0123		
03/24/03	624	31	433	39.19	0.0115		
04/22/03	461	29	463	30.95	0.0091		
05/21/03	603	29	492	40.48	0.0119		
06/19/03	536	29	521	35.98	0.0105	536	536
07/23/03	936	34	552	53.60	0.0157	936	936
08/19/03	1433	27	583	103.33	0.0303	1433	1433
09/18/03	971	30	611	63.02	0.0185		
10/20/03	653	32	642	39.73	0.0116		
11/18/03	550	29	673	36.92	0.0108		
12/18/03	736	30	702	47.76	0.0140		
						5645	**5645**

Table B.27a. Natural gas data for Home C-7 (ranch).

Reading Date	Therms	cycle days	day	Btu/sqft-day	kWh/sqft-day	HDD/day	Btu/h	Btu (HDD)	Btu (HDD)
01/29/02	154	34	12	294.42	0.0863	38.22		15,375,864	
02/26/02	130	28	43	303.41	0.0889	30.38		13,049,253	
03/26/02	116	28	71	270.49	0.0793	23.30		11,633,055	
04/29/02	74	34	102	141.40	0.0414	15.46		7,384,461	
05/29/02	38	30	134	83.42	0.0244	7.37		3,843,966	
06/26/02	14	28	163	32.93	0.0096	0.00			
07/29/02	17	33	194	33.93	0.0099	0.00			
08/27/02	12	29	225	27.25	0.0080	0.00			
09/26/02	14	30	254	30.73	0.0090	0.00			
10/28/02	40	32	285	82.32	0.0241	12.05	5268.59	4,046,280	4,046,280
11/25/02	74	28	315	171.70	0.0503	21.97	10988.78	7,384,461	7,384,461
12/26/02	63	31	345	131.71	0.0386	31.73	8429.75	6,271,734	6,271,734
01/27/03	119	32	376	242.85	0.0712	42.14	15542.35	11,936,526	11,936,526
02/25/03	78	29	407	174.86	0.0512	36.77	11191.22	7,789,089	7,789,089
03/26/03	73	29	436	163.51	0.0479	26.52	10464.52	7,283,304	7,283,304
04/29/03	39	34	467	75.54	0.0221	15.37	4834.71	3,945,123	3,945,123
05/28/03	18	29	499	40.88	0.0120	4.23	2616.13	1,820,826	1,820,826
06/26/03	13	29	528	29.52	0.0087	0.00			
07/29/03	18	33	559	35.92	0.0105	0.00			
08/26/03	13	28	589	30.58	0.0090	0.00			
09/25/03	14	30	618	30.73	0.0090	2.41		1,416,198	
10/28/03	27	33	650	53.88	0.0158	13.06		2,731,239	
11/25/03	64	28	680	148.18	0.0434	23.37		6,372,891	
12/29/03	125	34	711	240.19	0.0704	33.85		12,543,468	
						UA =	**297.617**	**124,827,738**	**50,477,343**
							1569.214		

Table B.27b. Electricity data for Home C-7 (ranch).

Reading Date	kWh	cycle days	day	Btu/sqft-day	kWh/sqft-day	kWh (CDD)	kWh (CDD)
01/24/02	746	34	7	48.75	0.0143		
02/27/02	702	34	41	45.88	0.0134		
03/26/02	568	27	72	46.74	0.0137		
04/25/02	488	30	100	36.14	0.0106		
05/23/02	647	28	129	51.34	0.0150		
06/26/02	716	34	160	46.79	0.0137	716	
07/24/02	1010	28	191	80.15	0.0235	1010	
08/22/02	918	29	220	70.34	0.0206	918	
09/24/02	950	33	251	63.97	0.0187		
10/24/02	711	30	282	52.66	0.0154		
11/21/02	637	28	311	50.55	0.0148		
12/26/02	432	35	343	27.43	0.0080		
01/28/03	493	33	377	33.20	0.0097		
02/26/03	284	29	408	21.76	0.0064		
03/27/03	326	29	437	24.98	0.0073		
04/25/03	361	29	466	27.66	0.0081		
05/28/03	521	33	497	35.08	0.0103		
06/25/03	605	28	527	48.01	0.0141	605	605
07/25/03	930	30	556	68.88	0.0202	930	930
08/25/03	1147	31	587	82.21	0.0241	1147	1147
09/24/03	991	30	617	73.40	0.0215		
10/23/03	994	29	647	76.16	0.0223		
11/24/03	1042	32	677	72.35	0.0212		
12/26/03	1222	32	709	84.85	0.0249		
						5326	**2682**

Table B.28a. Natural gas data for Home C-8 (ranch).

Reading Date	Therms	cycle days	day	Btu/sqft-day	kWh/sqft-day	HDD/day	Btu/h	Btu (HDD)	Btu (HDD)
01/29/02	94	34	12	197.64	0.0579	38.22		9,407,601	
02/26/02	75	28	43	190.96	0.0560	30.38		7,485,618	
03/26/02	81	28	71	206.44	0.0605	23.30		8,092,560	
04/29/02	59	34	102	123.26	0.0361	15.46		5,867,106	
05/29/02	25	30	134	60.21	0.0176	7.37		2,528,925	
06/26/02	3	28	163	7.74	0.0023	0.00			
07/29/02	4	33	194	8.76	0.0026	0.00			
08/27/02	3	29	225	7.47	0.0022	0.00			
09/26/02	3	30	254	7.23	0.0021	0.00			
10/28/02	29	32	285	65.48	0.0192	12.05	3819.73	2,933,553	2,933,553
11/25/02	57	28	315	144.51	0.0423	21.97	8429.75	5,664,792	5,664,792
12/26/02	85	31	345	195.79	0.0574	31.73	11420.95	8,497,188	8,497,188
01/27/03	102	32	376	228.05	0.0668	42.14	13303.20	10,216,857	10,216,857
02/25/03	99	29	407	244.17	0.0715	36.77	14243.37	9,913,386	9,913,386
03/26/03	72	29	436	176.90	0.0518	26.52	10319.18	7,182,147	7,182,147
04/29/03	53	34	467	110.51	0.0324	15.37	6446.28	5,260,164	5,260,164
05/28/03	21	29	499	52.32	0.0153	4.23	3052.15	2,124,297	2,124,297
06/26/03	5	29	528	12.46	0.0037	0.00			
07/29/03	4	33	559	8.76	0.0026	0.00			
08/26/03	3	28	589	7.74	0.0023	0.00			
09/25/03	2	30	618	4.82	0.0014	2.41		202,314	
10/28/03	29	33	650	63.50	0.0186	13.06		2,933,553	
11/25/03	50	28	680	126.45	0.0370	23.37		4,956,693	
12/29/03	99	34	711	208.26	0.0610	33.85		9,913,386	
						UA =	**315.863**	**103,180,140**	**51,792,384**
							1346.388		

Table B.28b. Electricity data for Home C-8 (ranch).

Reading Date	kWh	cycle days	day	Btu/sqft-day	kWh/sqft-day	kWh (CDD)	kWh (CDD)
01/24/02	1173	34	7	84.11	0.0246		
02/27/02	902	34	41	64.67	0.0189		
03/26/02	763	27	72	68.89	0.0202		
04/25/02	788	30	100	64.03	0.0188		
05/23/02	658	28	129	57.29	0.0168		
06/26/02	1045	34	160	74.93	0.0220	1045	
07/24/02	986	28	191	85.85	0.0252	986	
08/22/02	954	29	220	80.20	0.0235	954	
09/24/02	949	33	251	70.11	0.0205		
10/24/02	734	30	282	59.65	0.0175		
11/21/02	880	28	311	76.62	0.0224		
12/26/02	1278	35	343	89.02	0.0261		
01/28/03	1261	33	377	93.15	0.0273		
02/26/03	1043	29	408	87.68	0.0257		
03/27/03	859	29	437	72.21	0.0212		
04/25/03	749	29	466	62.96	0.0184		
05/28/03	917	33	497	67.74	0.0198		
06/25/03	1090	28	527	94.90	0.0278	1090	1090
07/25/03	1200	30	556	97.51	0.0286	1200	1200
08/25/03	1270	31	587	99.87	0.0293	1270	1270
09/24/03	957	30	617	77.77	0.0228		
10/23/03	761	29	647	63.97	0.0187		
11/24/03	902	32	677	68.72	0.0201		
12/26/03	1028	32	709	78.32	0.0229		
						6545	**3560**

Table B.29a. Natural gas data for Home C-9 (ranch).

Reading Date	Therms	cycle days	day	Btu/sqft-day	kWh/sqft-day	HDD/day	Btu/h	Btu (HDD)	Btu (HDD)
01/29/02	123	34	12	223.51	0.0655	38.22		12,341,154	
02/26/02	97	28	43	213.56	0.0626	30.38		9,711,072	
03/26/02	99	28	71	218.01	0.0639	23.30		9,913,386	
04/29/02	62	34	102	111.75	0.0327	15.46		6,170,577	
05/29/02	30	30	134	62.29	0.0183	7.37		3,034,710	
06/26/02	19	28	163	42.27	0.0124	0.00			
07/29/02	18	33	194	33.98	0.0100	0.00			
08/27/02	16	29	225	34.37	0.0101	0.00			
09/26/02	17	30	254	35.30	0.0103	0.00			
10/28/02	34	32	285	66.18	0.0194	12.05	4478.30	3,439,338	3,439,338
11/25/02	75	28	315	164.62	0.0482	21.97	11139.31	7,485,618	7,485,618
12/26/02	111	31	345	221.02	0.0648	31.73	14956.01	11,127,270	11,127,270
01/27/03	153	32	376	293.93	0.0861	42.14	19888.94	15,274,707	15,274,707
02/25/03	137	29	407	289.97	0.0850	36.77	19620.97	13,656,195	13,656,195
03/26/03	108	29	436	229.82	0.0673	26.52	15551.44	10,823,799	10,823,799
04/29/03	60	34	467	108.09	0.0317	15.37	7314.05	5,968,263	5,968,263
05/28/03	28	29	499	60.14	0.0176	4.23	4069.53	2,832,396	2,832,396
06/26/03	18	29	528	38.66	0.0113	0.00			
07/29/03	13	33	559	24.54	0.0072	0.00			
08/26/03	11	28	589	24.47	0.0072	0.00			
09/25/03	14	30	618	29.07	0.0085	2.41		1,416,198	
10/28/03	30	33	650	56.63	0.0166	13.06		3,034,710	
11/25/03	72	28	680	157.95	0.0463	23.37		7,182,147	
12/29/03	138	34	711	249.16	0.0730	33.85		13,757,352	
						UA =	**479.633**	**137,168,892**	**70,607,586**
							688.651		

Table B.29b. Electricity data for Home C-9 (ranch).

Reading Date	kWh	cycle days	day	Btu/sqft-day	kWh/sqft-day	kWh (CDD)	kWh (CDD)
02/27/02	795	68	24	24.57	0.0072		
03/26/02	609	27	72	47.40	0.0139		
04/25/02	641	30	100	44.90	0.0132		
05/23/02	652	28	129	48.94	0.0143		
06/26/02	580	34	160	35.85	0.0105	580	
07/24/02	925	28	191	69.43	0.0203	925	
08/22/02	695	29	220	50.37	0.0148	695	
09/24/02	744	33	251	47.38	0.0139		
10/24/02	586	30	282	41.05	0.0120		
11/21/02	692	28	311	51.94	0.0152		
12/26/02	1017	35	343	61.07	0.0179		
01/28/03	822	33	377	52.35	0.0153		
02/26/03	707	29	408	51.24	0.0150		
03/27/03	707	29	437	51.24	0.0150		
04/25/03	600	29	466	43.48	0.0127		
05/28/03	618	33	497	39.36	0.0115		
06/25/03	483	28	527	36.25	0.0106	483	483
07/25/03	524	30	556	36.71	0.0108	524	524
08/25/03	823	31	587	55.79	0.0163	823	823
09/24/03	576	30	617	40.35	0.0118		
10/23/03	431	29	647	31.23	0.0092		
11/24/03	520	32	677	34.15	0.0100		
12/26/03	659	32	709	43.28	0.0127		
01/27/04	571	32	741	37.50	0.0110		
						4030	**1830**

Table B.30a. Natural gas data for Home C-10 (2-story).

Reading Date	Therms	cycle days	day	Btu/sqft-day	kWh/sqft-day	HDD/day	Btu/h	Btu (HDD)	Btu (HDD)
02/01/02	122	30	17	199.25	0.0584	36.96		12,200,000	
03/05/02	127	32	48	194.45	0.0570	29.12		12,700,000	
04/04/02	93	30	79	151.89	0.0445	21.28		9,300,000	
05/02/02	41	28	108	71.74	0.0210	13.94		4,100,000	
06/03/02	31	32	138	47.46	0.0139	6.36		3,100,000	
07/02/02	21	29	169	35.48	0.0104	0.00			
08/01/02	19	30	198	31.03	0.0091	0.00			
08/29/02	14	28	227	24.50	0.0072	0.00			
10/01/02	15	33	258	22.27	0.0065	0.00			
10/30/02	42	29	289	70.96	0.0208	13.21	6034.48	4,200,000	4,200,000
12/02/02	104	33	320	154.41	0.0452	23.46	13131.31	10,400,000	10,400,000
01/03/03	120	32	352	183.73	0.0538	34.20	15625.00	12,000,000	12,000,000
02/03/03	165	31	384	260.78	0.0764	44.91	22177.42	16,500,000	16,500,000
03/05/03	163	30	414	266.21	0.0780	34.12	22638.89	16,300,000	16,300,000
04/03/03	81	29	444	136.85	0.0401	23.69	11637.93	8,100,000	8,100,000
05/05/03	56	32	474	85.74	0.0251	12.90	7291.67	5,600,000	5,600,000
06/03/03	22	29	505	37.17	0.0109	2.11	3160.92	2,200,000	2,200,000
07/02/03	19	29	534	32.10	0.0094	0.00			
07/31/03	19	29	563	32.10	0.0094	0.00			
09/03/03	18	34	594	25.94	0.0076	0.00			
10/02/03	13	29	626	21.96	0.0064	4.95		1,300,000	
10/29/03	26	27	654	47.18	0.0138	14.41		2,600,000	
12/01/03	95	33	684	141.05	0.0413	24.55		9,500,000	
01/05/04	139	35	718	194.58	0.0570	36.04		13,900,000	
						UA=	**491.751**	**144,000,000**	**75,300,000**
							1118.939		

Table B.30b. Electricity data for Home C-10 (2-story).

Reading Date	kWh	cycle days	day	Btu/sqft-day	kWh/sqft-day	kWh (CDD)	kWh (CDD)
02/01/02	779	30	17	43.42	0.0127		
03/05/02	712	32	48	37.21	0.0109		
04/04/02	656	30	79	36.57	0.0107		
05/02/02	703	28	108	41.98	0.0123		
06/03/02	1090	32	138	56.96	0.0167		
07/02/02	1705	29	169	98.31	0.0288	1705	
08/01/02	1817	30	198	101.28	0.0297	1817	
08/29/02	1480	28	227	88.39	0.0259	1480	
10/01/02	1581	33	258	80.11	0.0235		
10/30/02	863	29	289	49.76	0.0146		
12/02/02	817	33	320	41.40	0.0121		
01/03/03	1260	32	352	65.84	0.0193		
02/03/03	789	31	384	42.56	0.0125		
03/05/03	690	30	414	38.46	0.0113		
04/03/03	552	29	444	31.83	0.0093		
05/05/03	727	32	474	37.99	0.0111		
06/03/03	935	29	505	53.91	0.0158		
07/02/03	1550	29	534	89.38	0.0262	1550	1550
07/31/03	1677	29	563	96.70	0.0283	1677	1677
09/03/03	1994	34	594	98.07	0.0287	1994	1994
10/02/03	1204	29	626	69.43	0.0203		
10/29/03	983	27	654	60.88	0.0178		
12/01/03	837	33	684	42.41	0.0124		
01/05/04	1420	35	718	67.84	0.0199		
						10223	**5221**

Appendix C

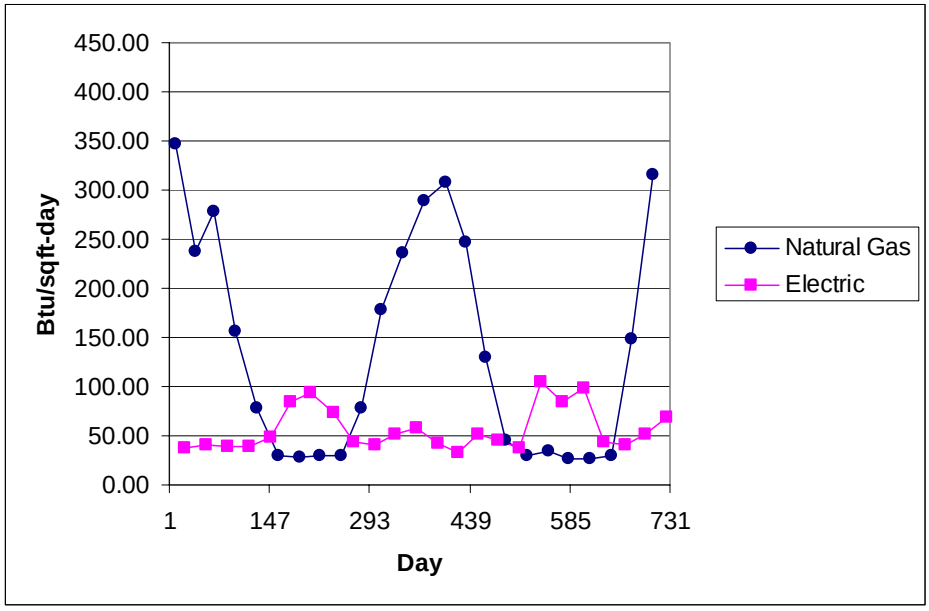


Figure C.1. Energy consumption versus day for Home A-1 (ranch).

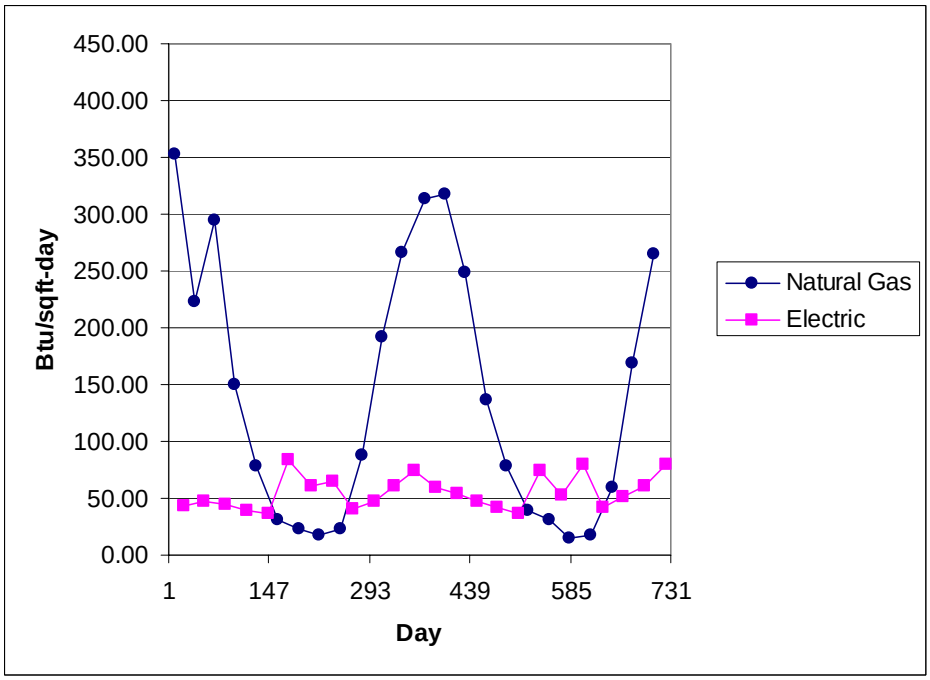


Figure C.2. Energy consumption versus day for Home A-2 (2-story).

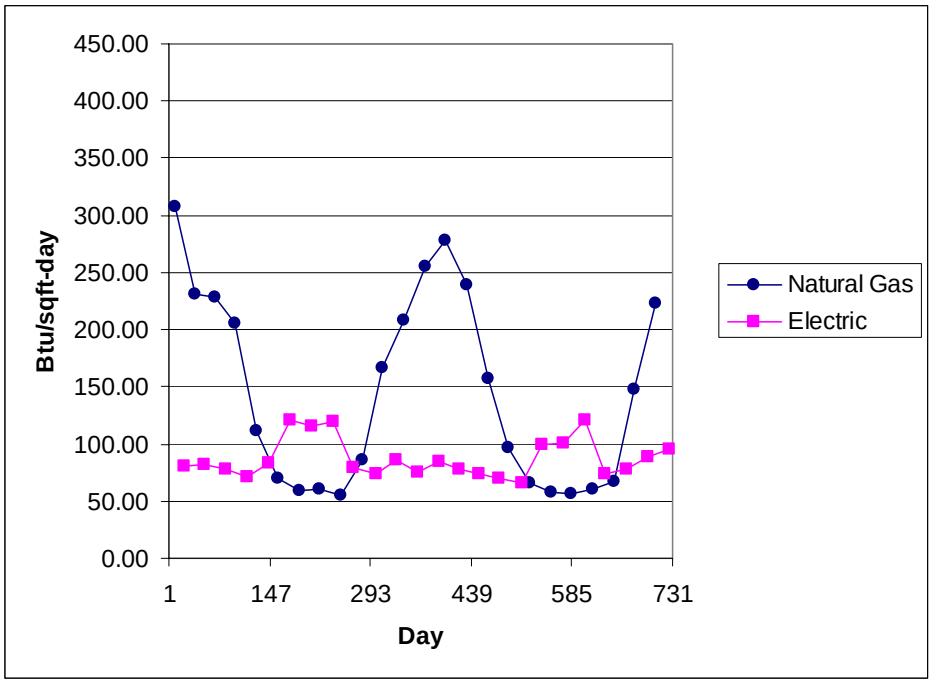


Figure C.3. Energy consumption versus day for Home A-3 (ranch).

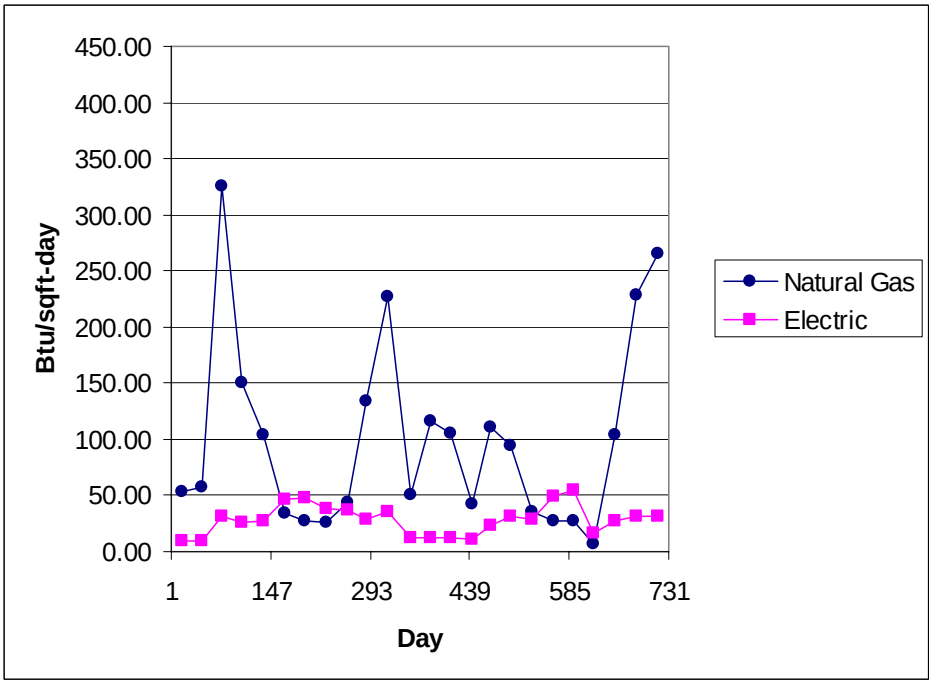


Figure C.4. Energy consumption versus day for Home A-4 (ranch).

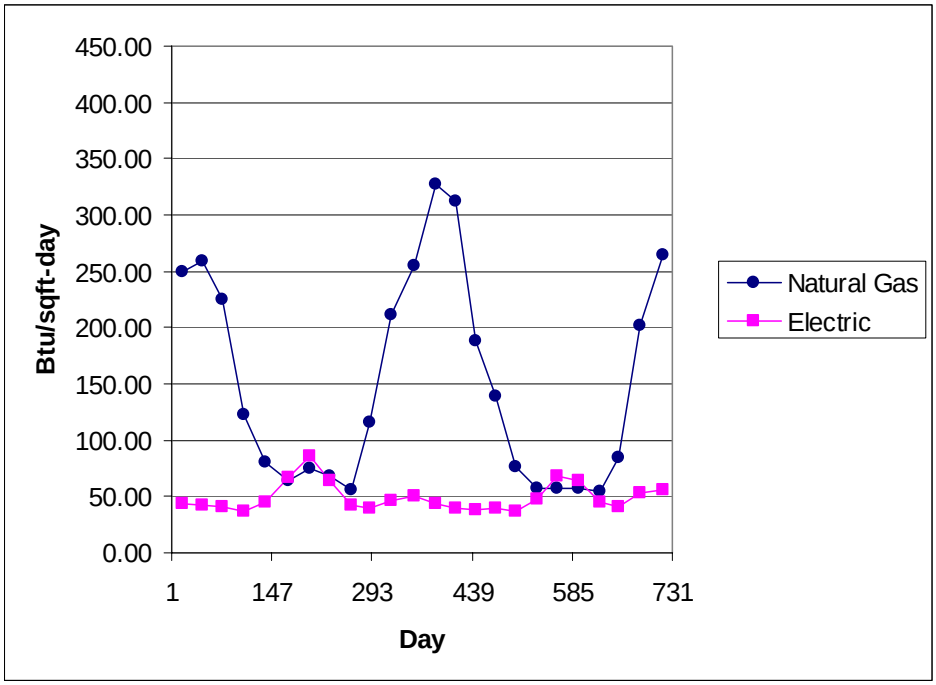


Figure C.5. Energy consumption versus day for Home A-5 (split-level).

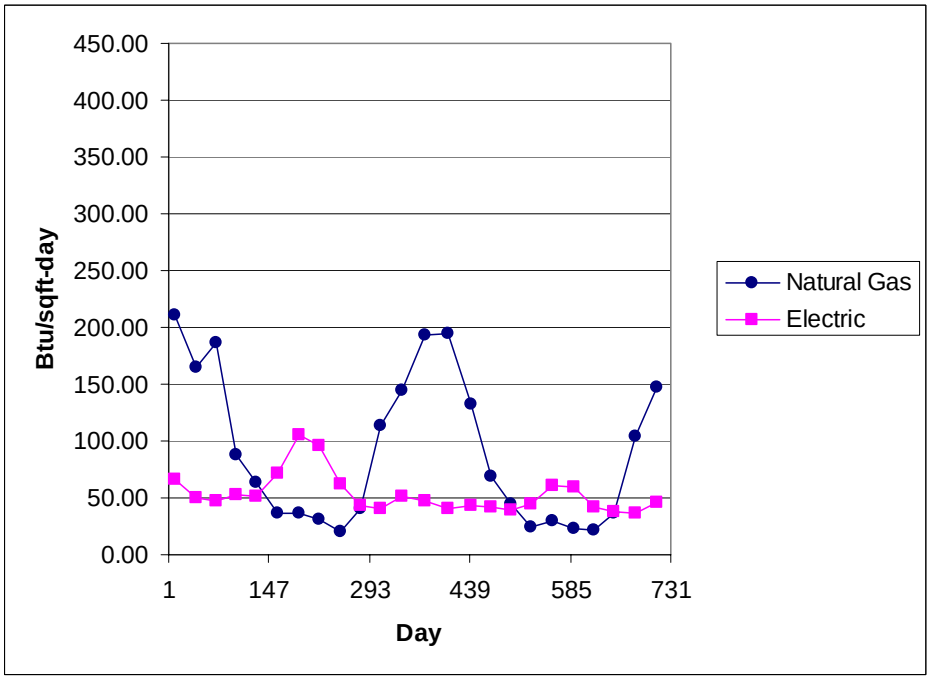


Figure C.6. Energy consumption versus day for Home A-6 (ranch).

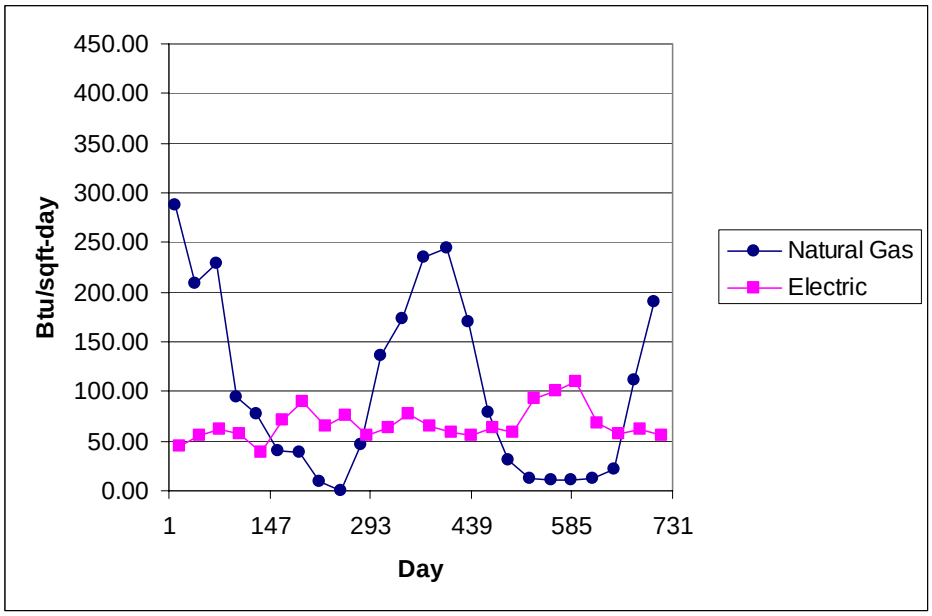


Figure C.7. Energy consumption versus day for Home A-7 (ranch).

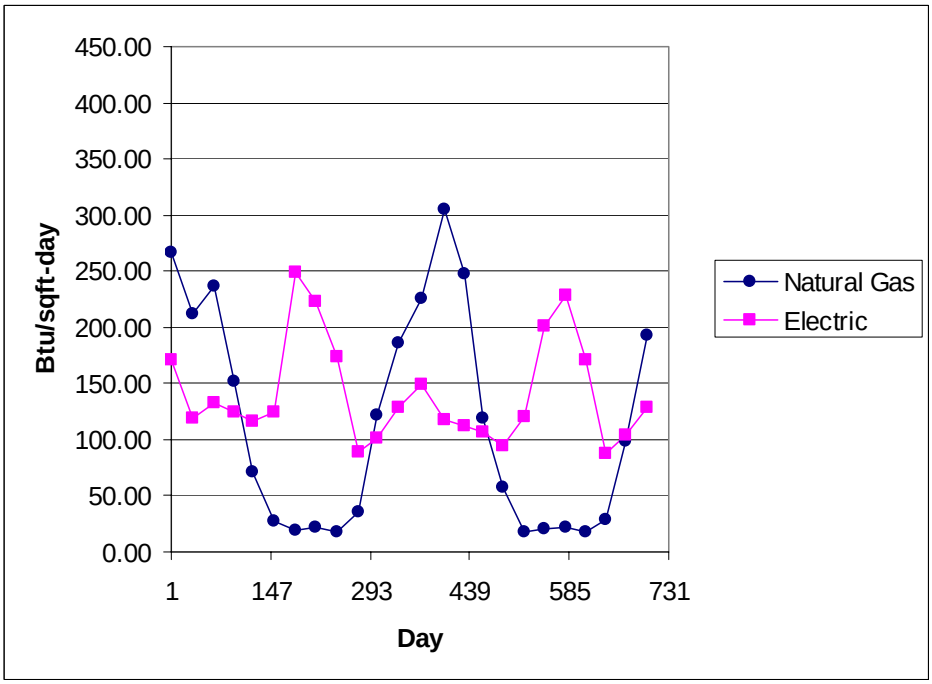


Figure C.8. Energy consumption versus day for Home A-8 (split-level).

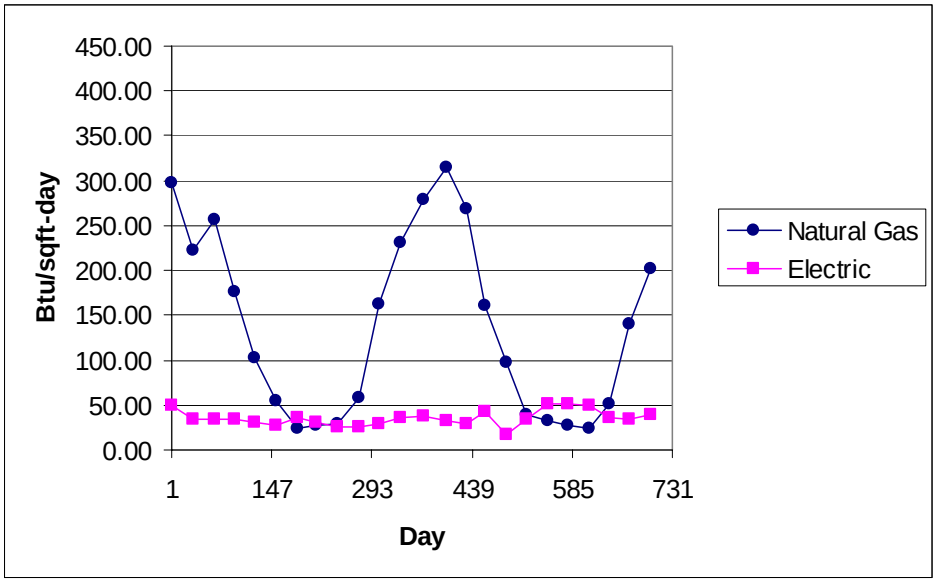


Figure C.9. Energy consumption versus day for Home A-9 (ranch).

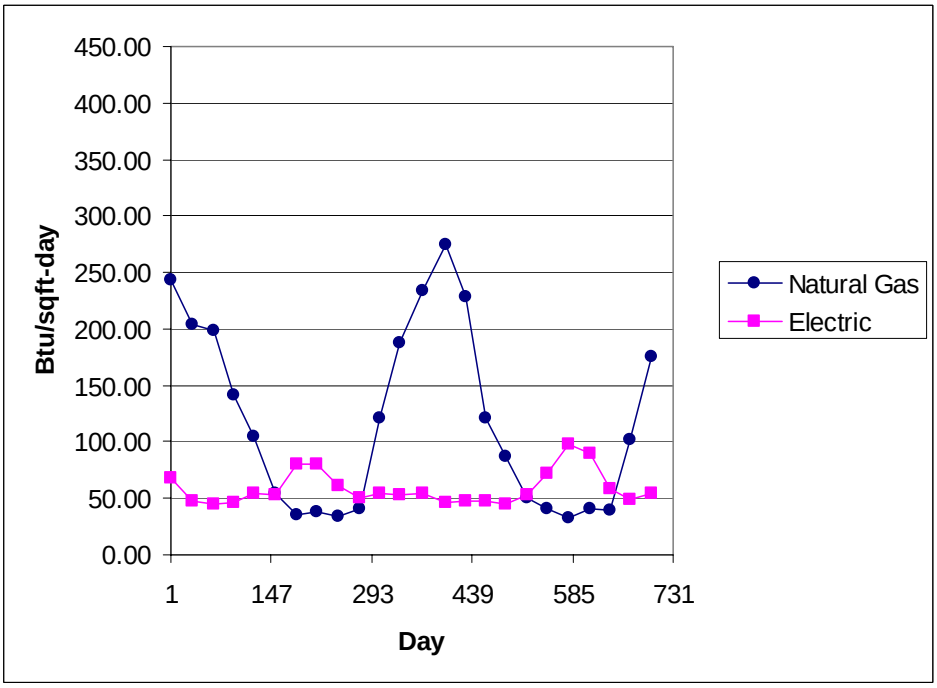


Figure C.10. Energy consumption versus day for Home A-10 (1-1/2 story).

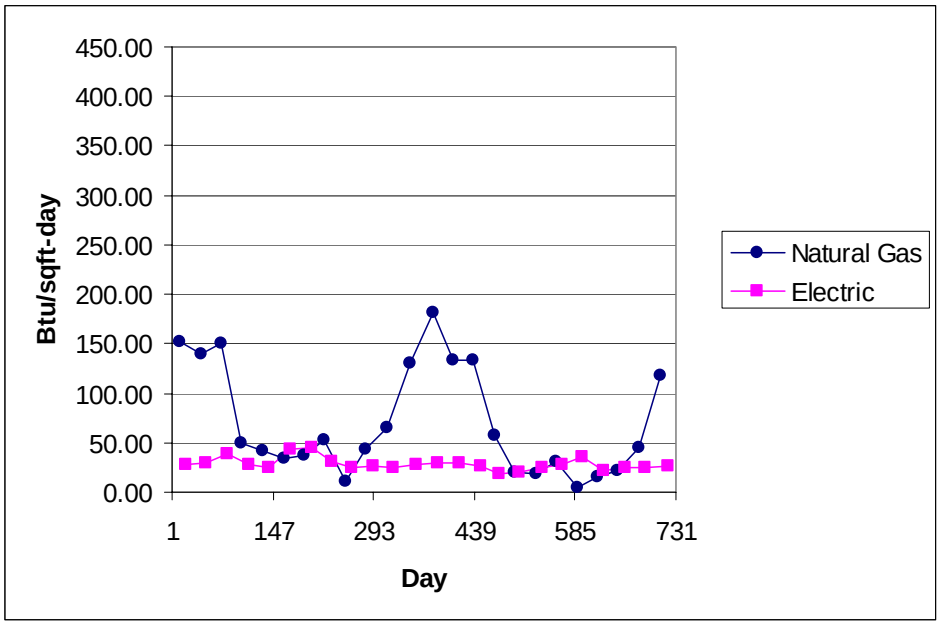


Figure C.11. Energy consumption versus day for Home B-1 (ranch).

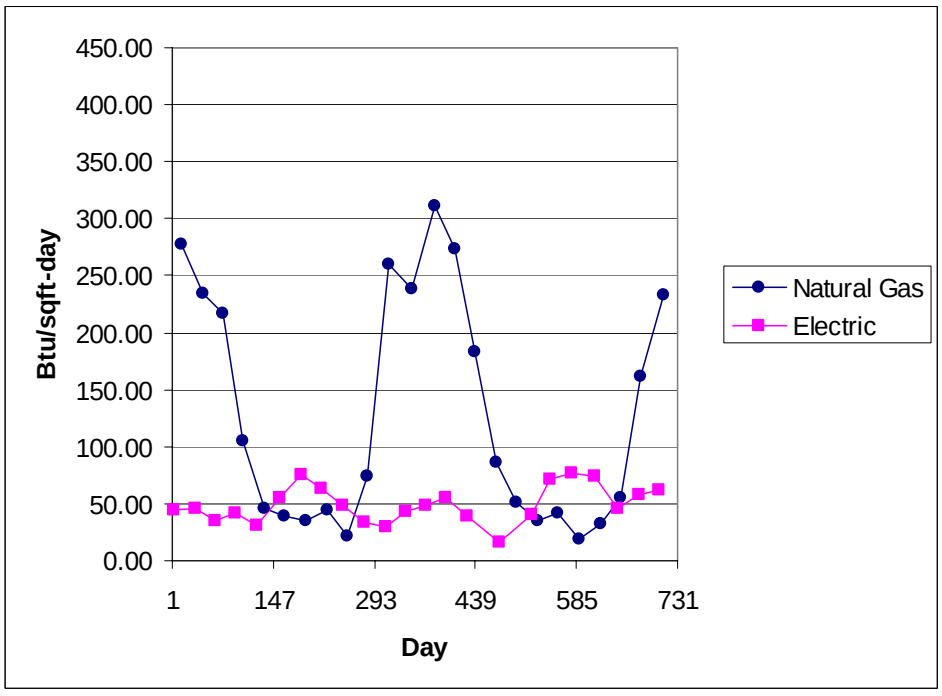


Figure C.12. Energy consumption versus day for Home B-2 (1-1/2 story).

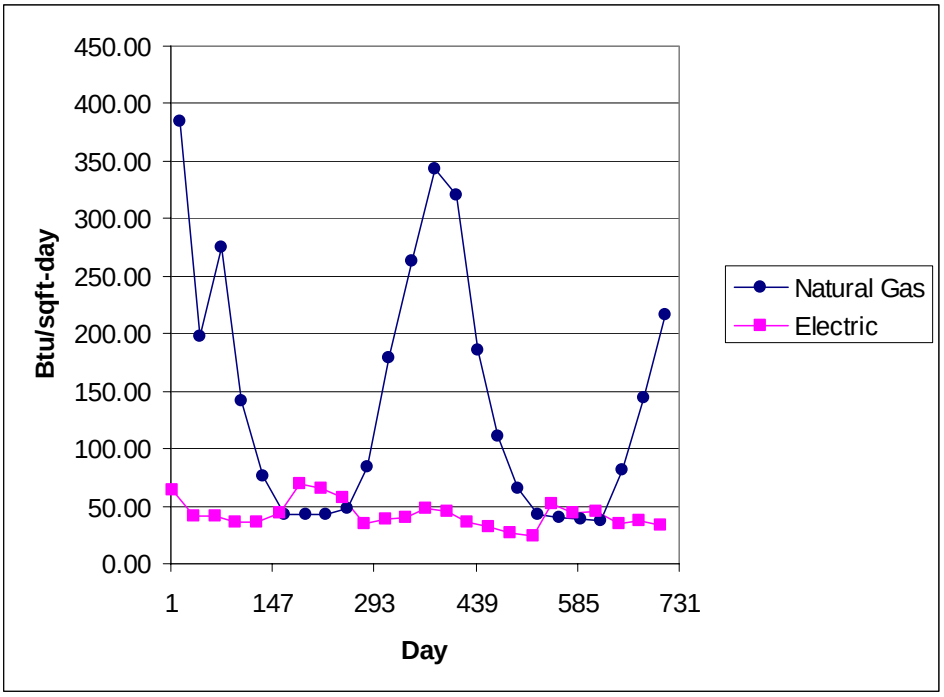


Figure C.13. Energy consumption versus day for Home B-3 (ranch).

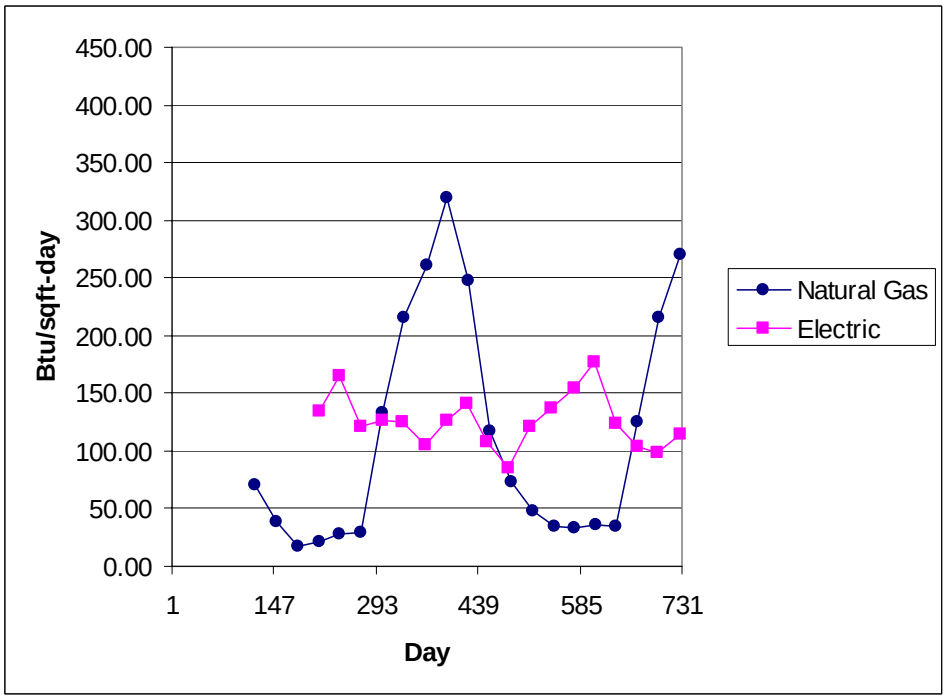


Figure C.14. Energy consumption versus day for Home B-4 (2-story).

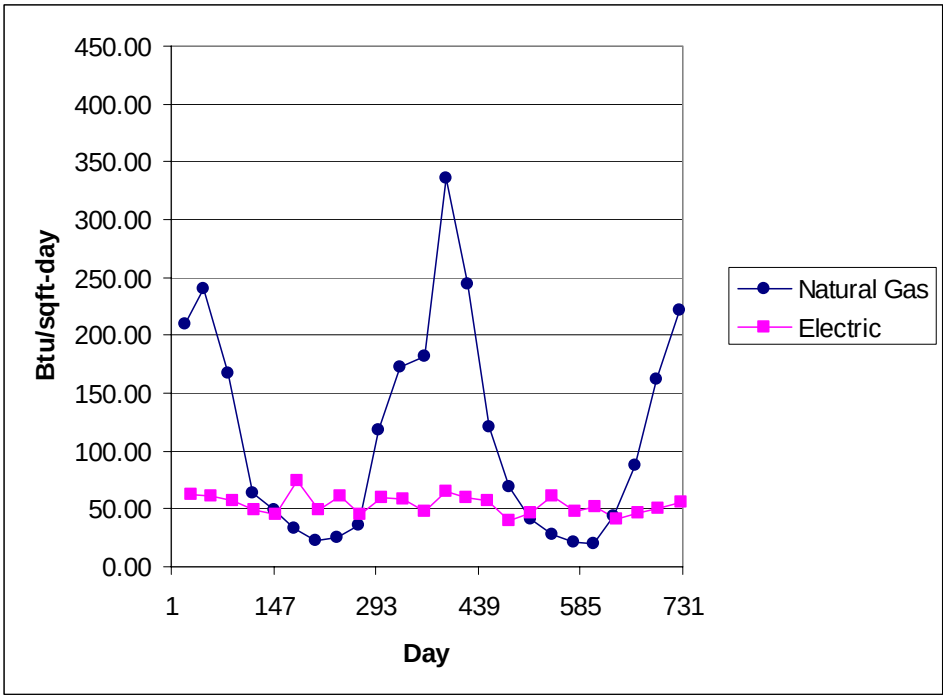


Figure C.15. Energy consumption versus day for Home B-5 (2-story).

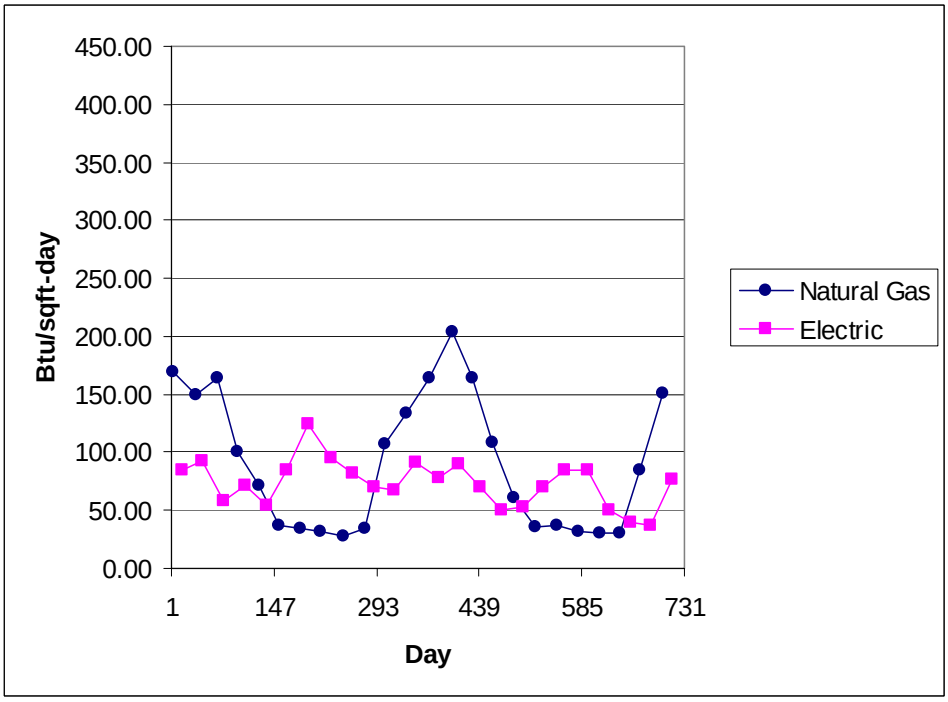


Figure C.16. Energy consumption versus day for Home B-6 (ranch).

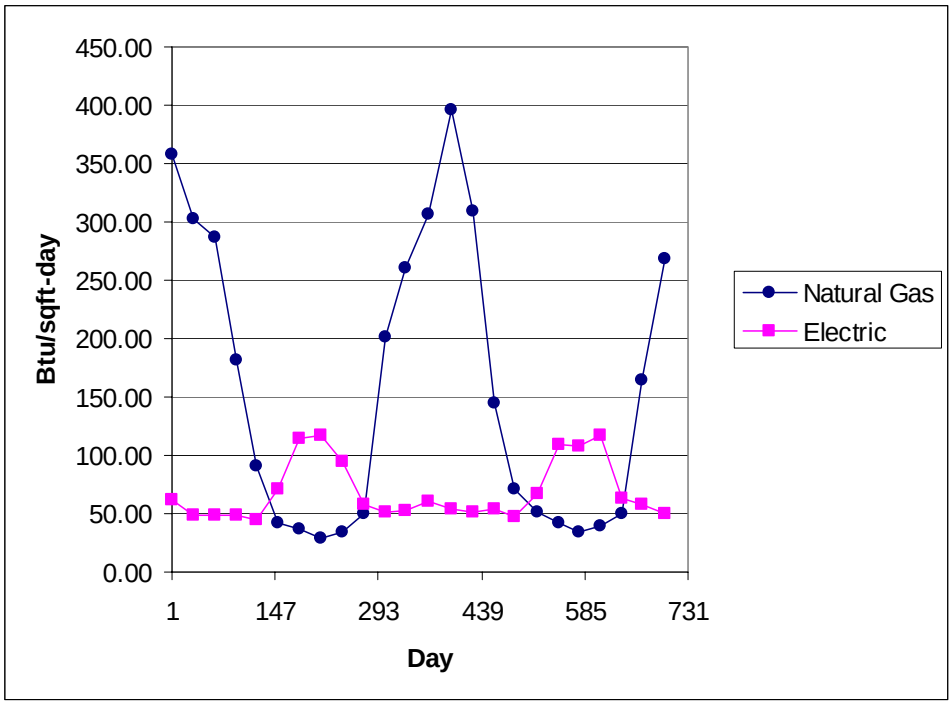


Figure C.17. Energy consumption versus day for Home B-7 (split-level).

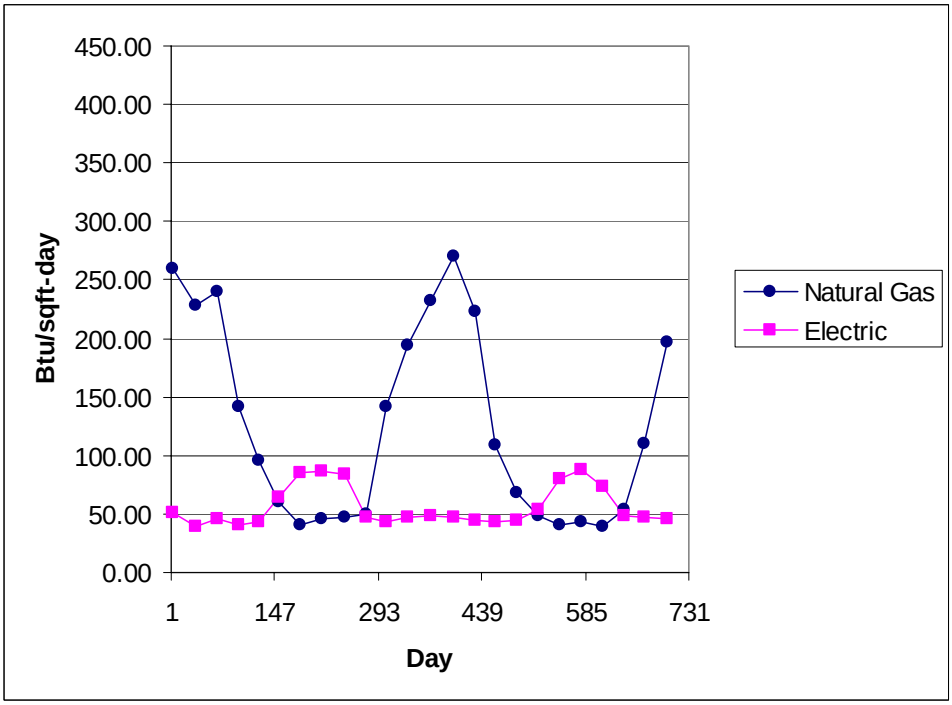


Figure C.18. Energy consumption versus day for Home B-8 (ranch).

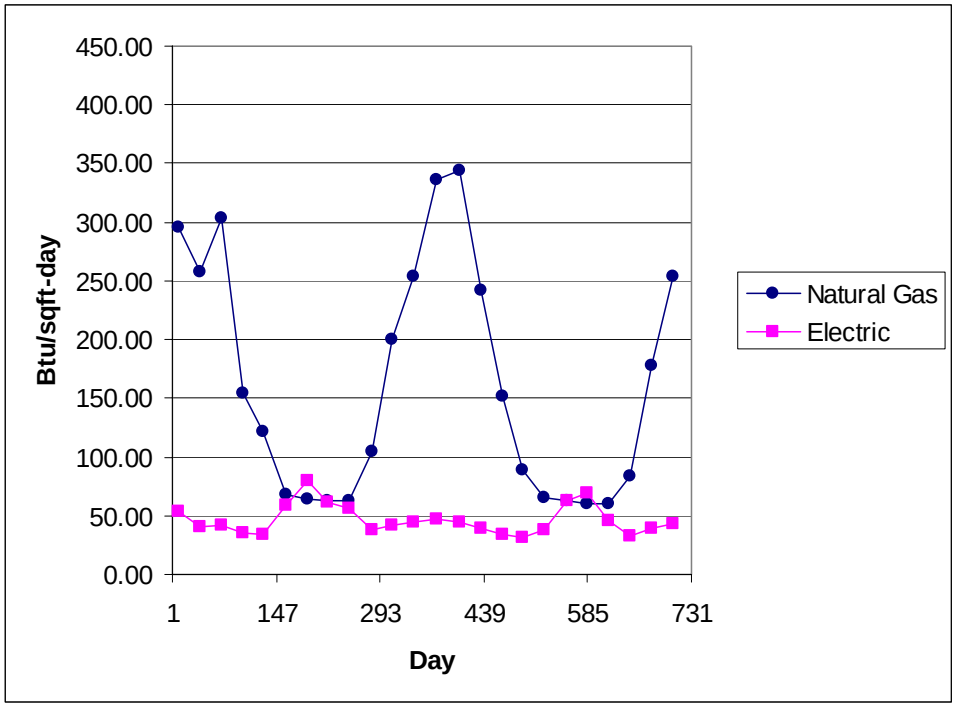


Figure C.19. Energy consumption versus day for Home B-9 (2-story).

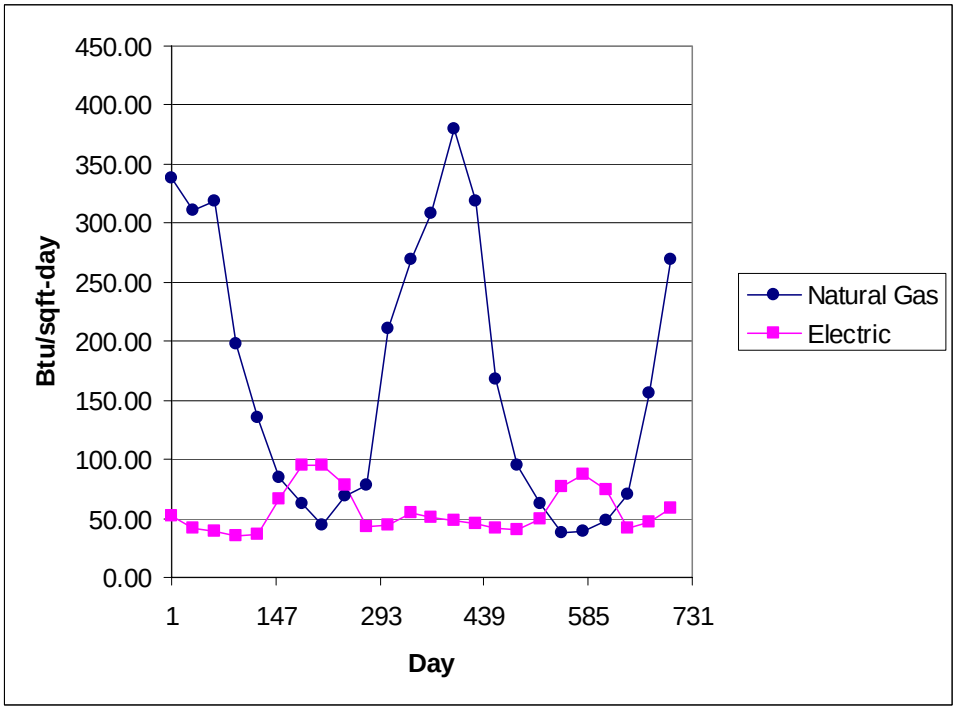


Figure C.20. Energy consumption versus day for Home B-10 (1-1/2 story).

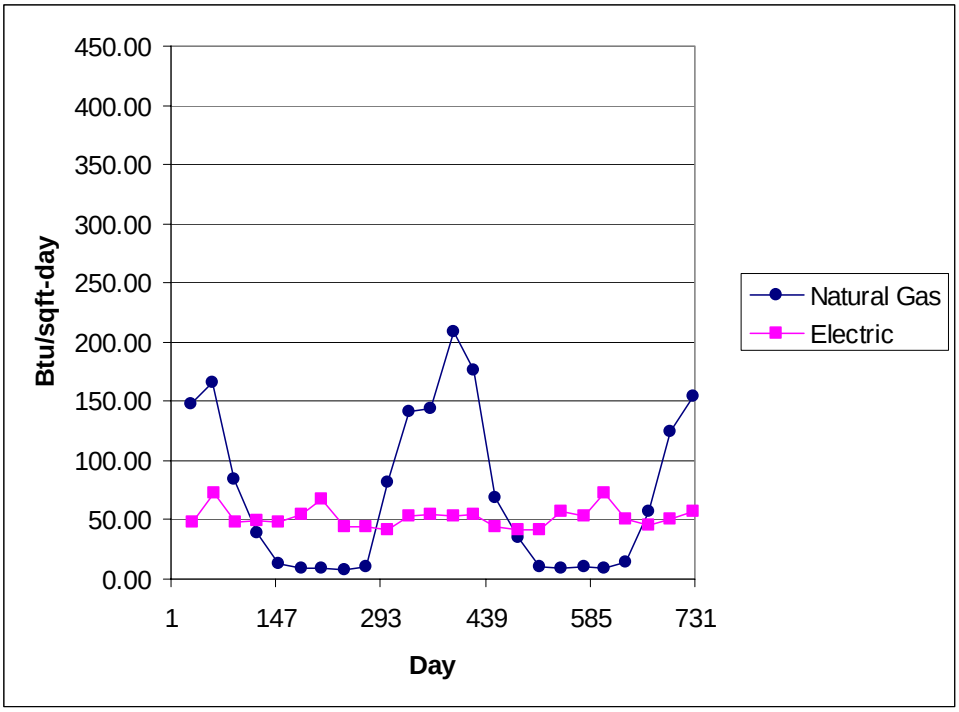


Figure C.21. Energy consumption versus day for Home C-1 (2-story).

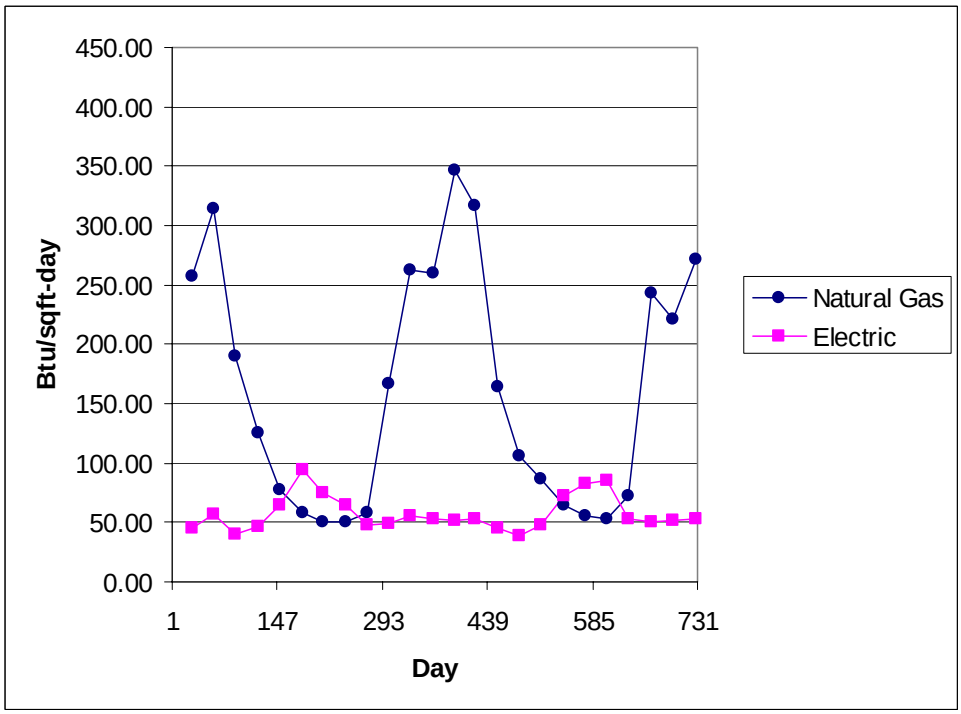


Figure C.22. Energy consumption versus day for Home C-2 (ranch).

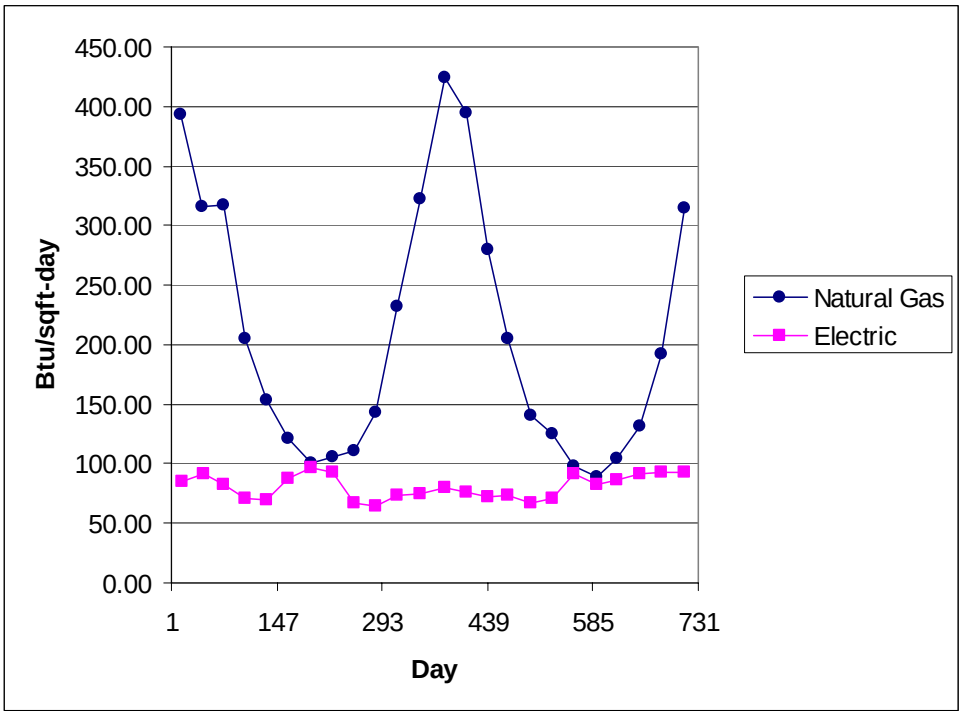


Figure C.23. Energy consumption versus day for Home C-3 (ranch).

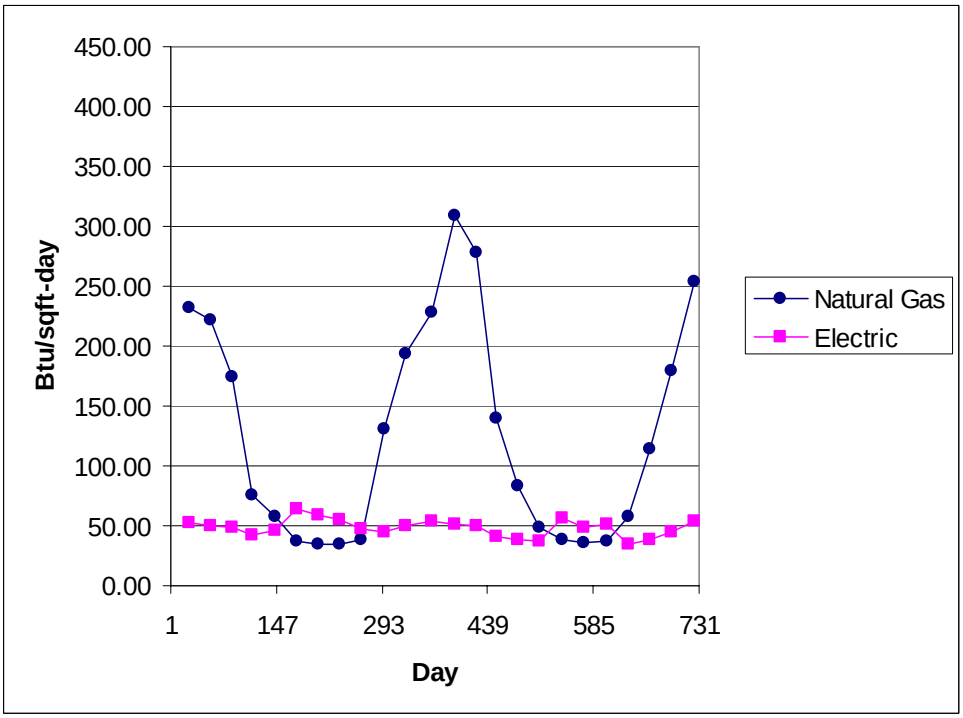


Figure C.24. Energy consumption versus day for Home C-4 (ranch).

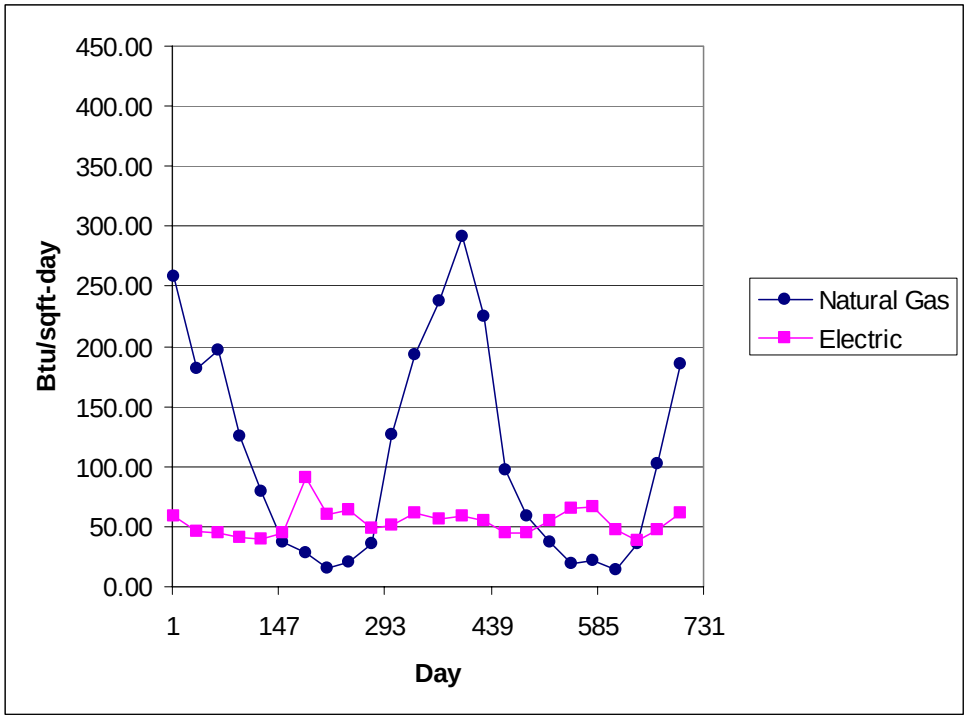


Figure C.25. Energy consumption versus day for Home C-5 (2-story).

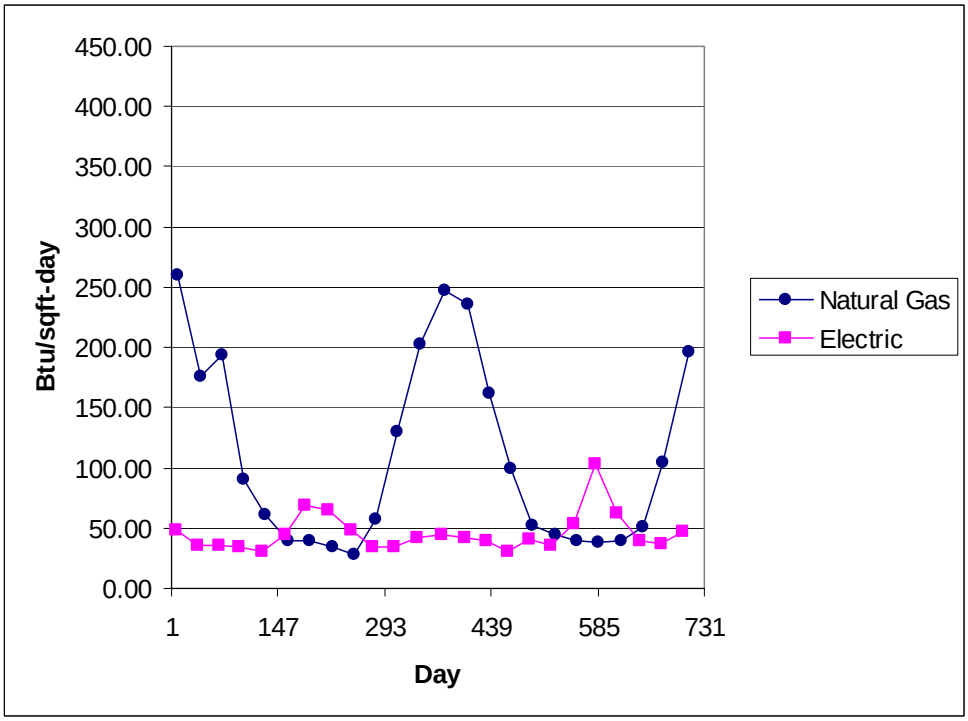


Figure C.26. Energy consumption versus day for Home C-6 (2-story).

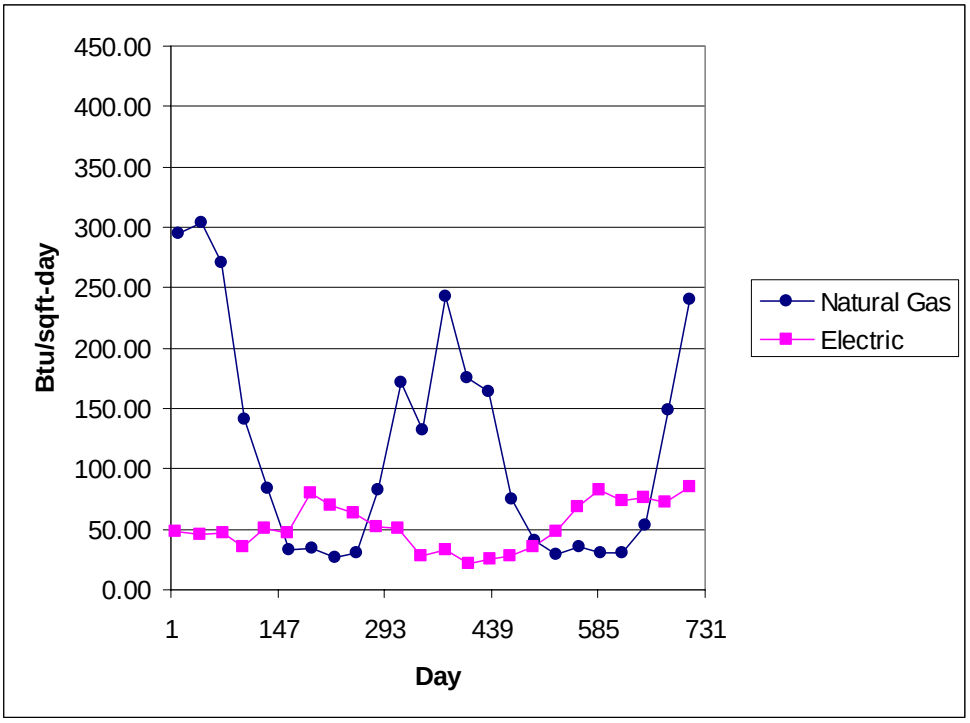


Figure C.27. Energy consumption versus day for Home C-7 (ranch).

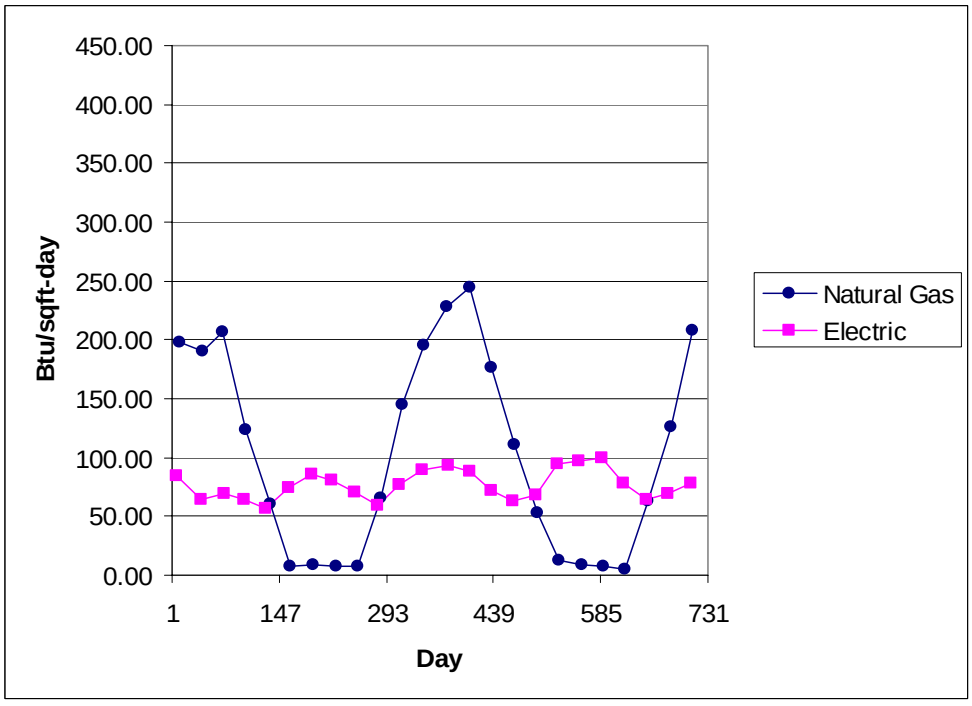


Figure C.28. Energy consumption versus day for Home C-8 (ranch).

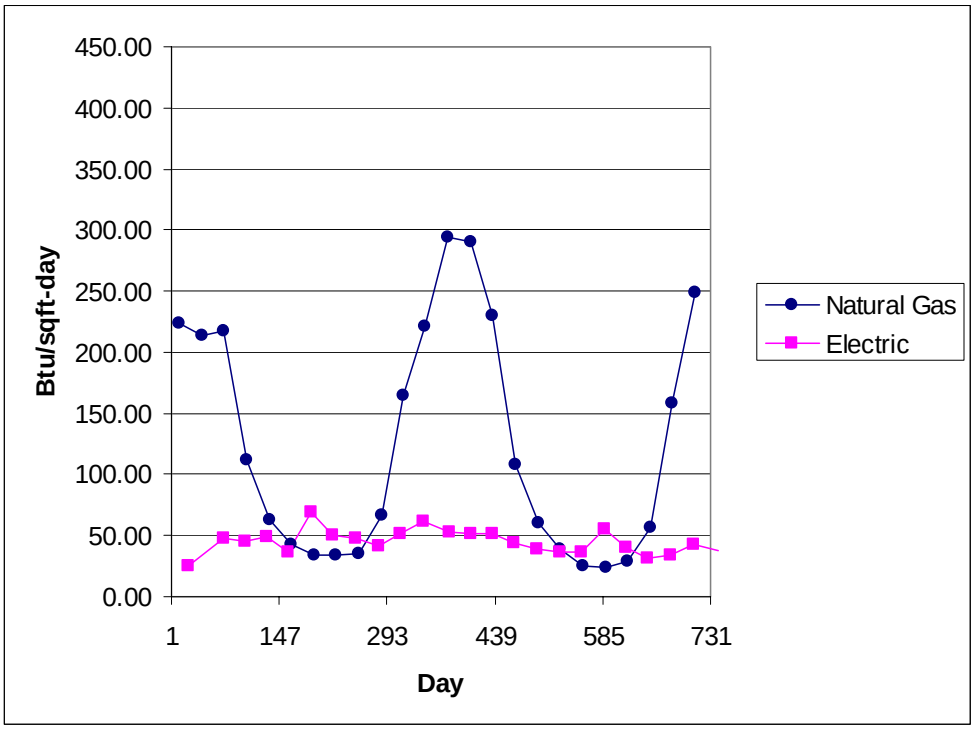


Figure C.29. Energy consumption versus day for Home C-9 (ranch).

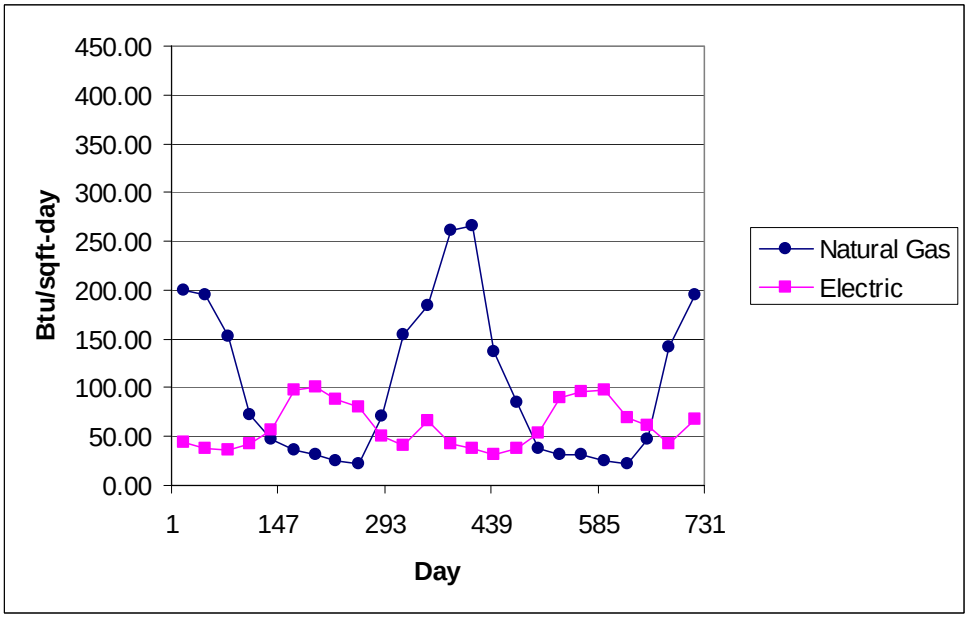


Figure C.30. Energy consumption versus day for Home C-10 (2-story).

Appendix D

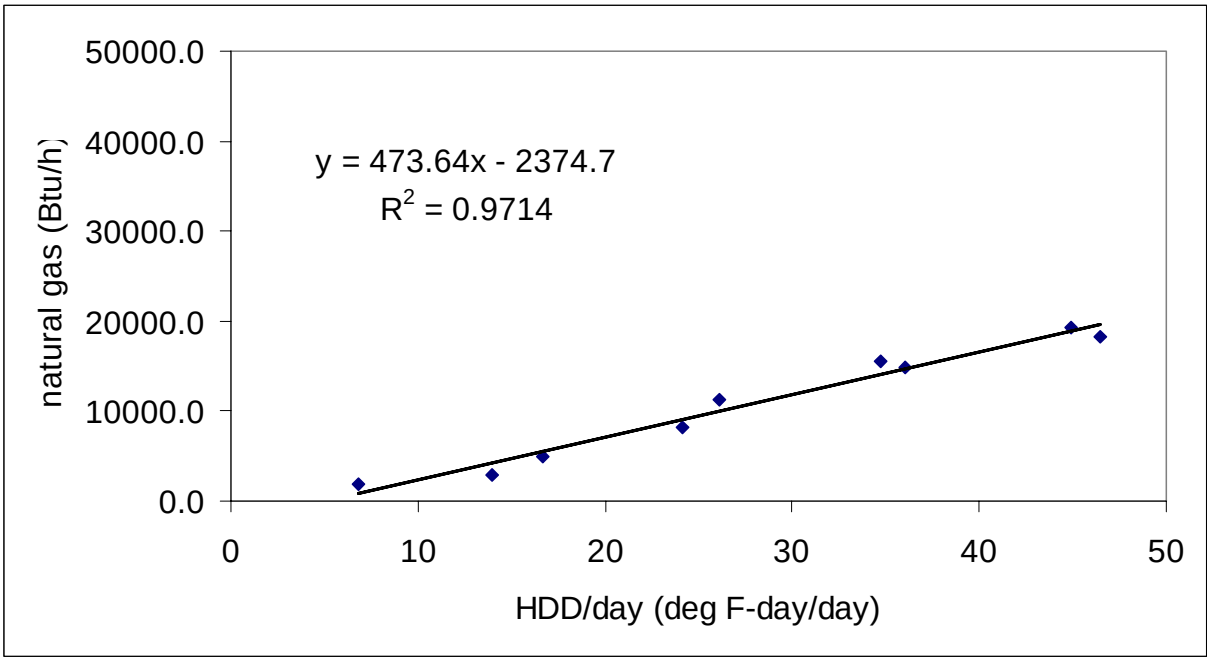


Figure D.1. Natural gas versus HDD/day for a one-year period for Home A-1 (ranch).

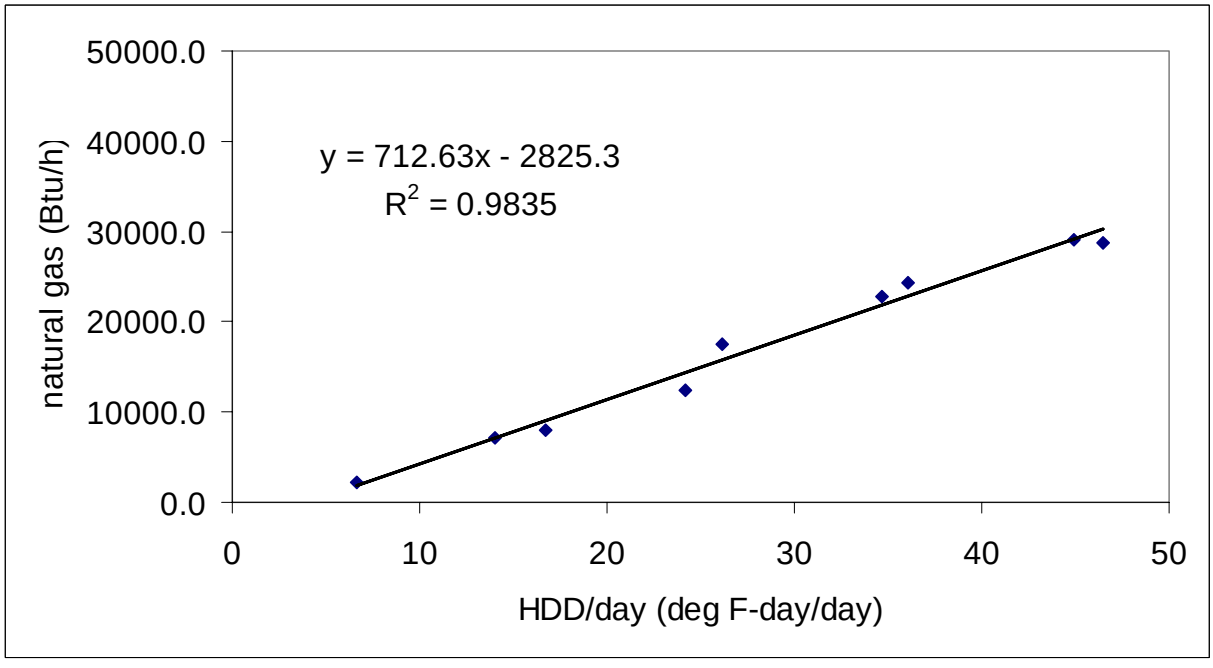


Figure D.2. Natural gas versus HDD/day for a one-year period for Home A-2 (2-story).

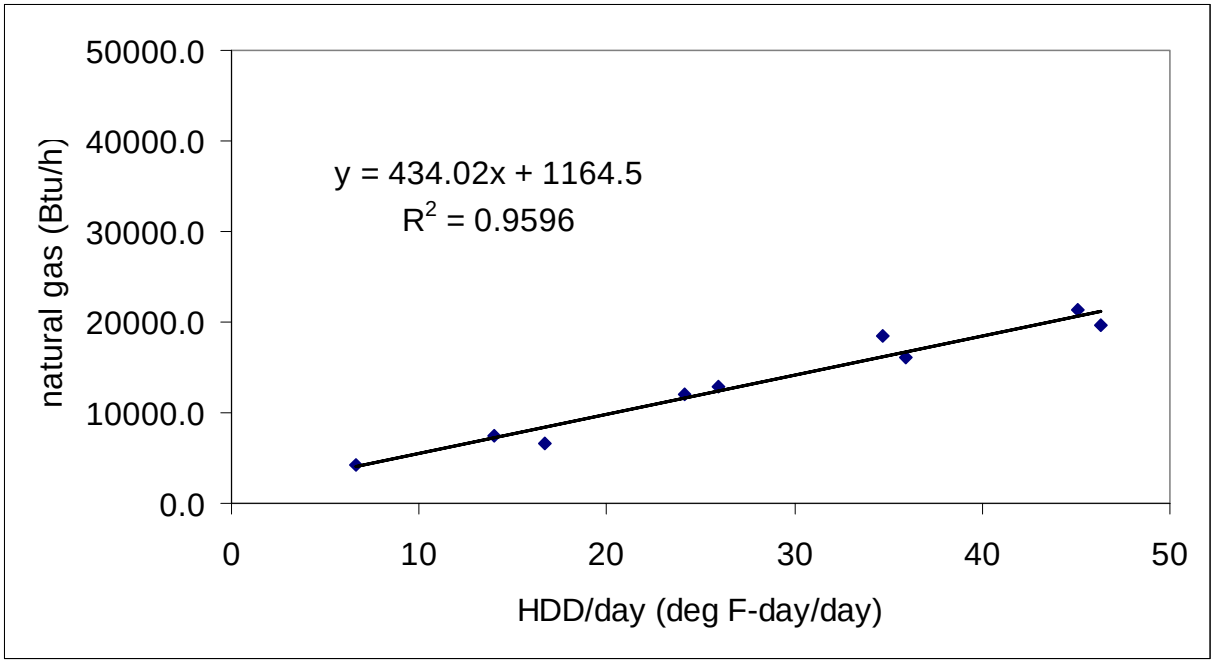


Figure D.3. Natural gas versus HDD/day for a one-year period for Home A-3 (ranch).

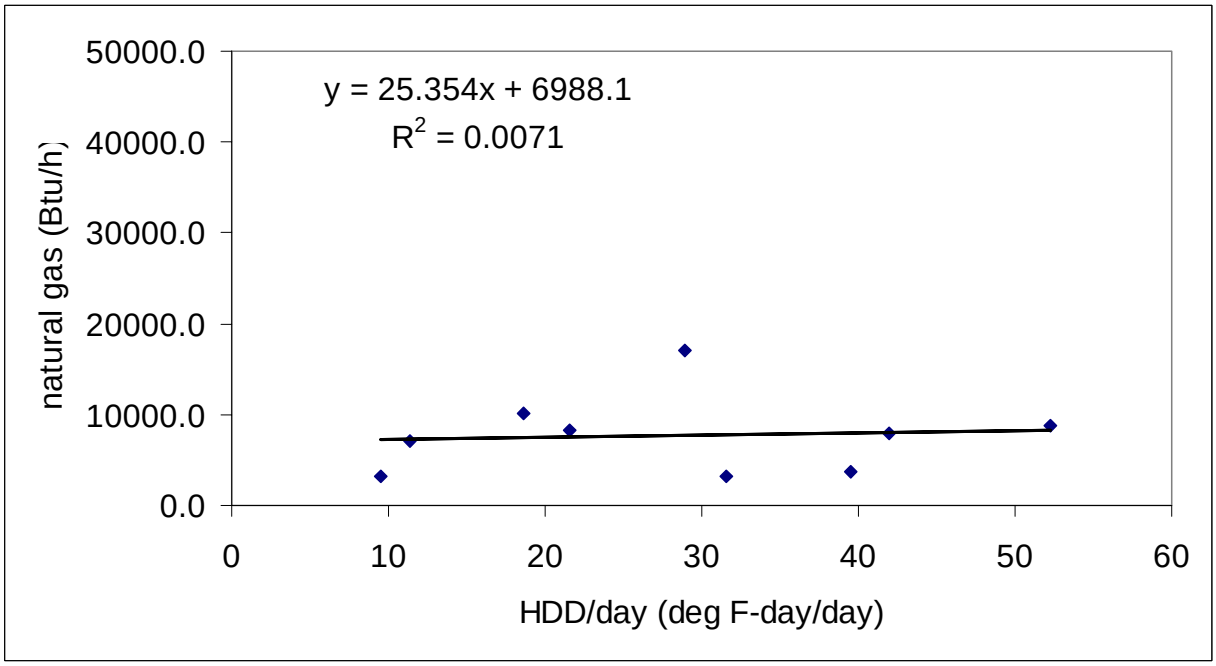


Figure D.4. Natural gas versus HDD/day for a one-year period for Home A-4 (ranch).

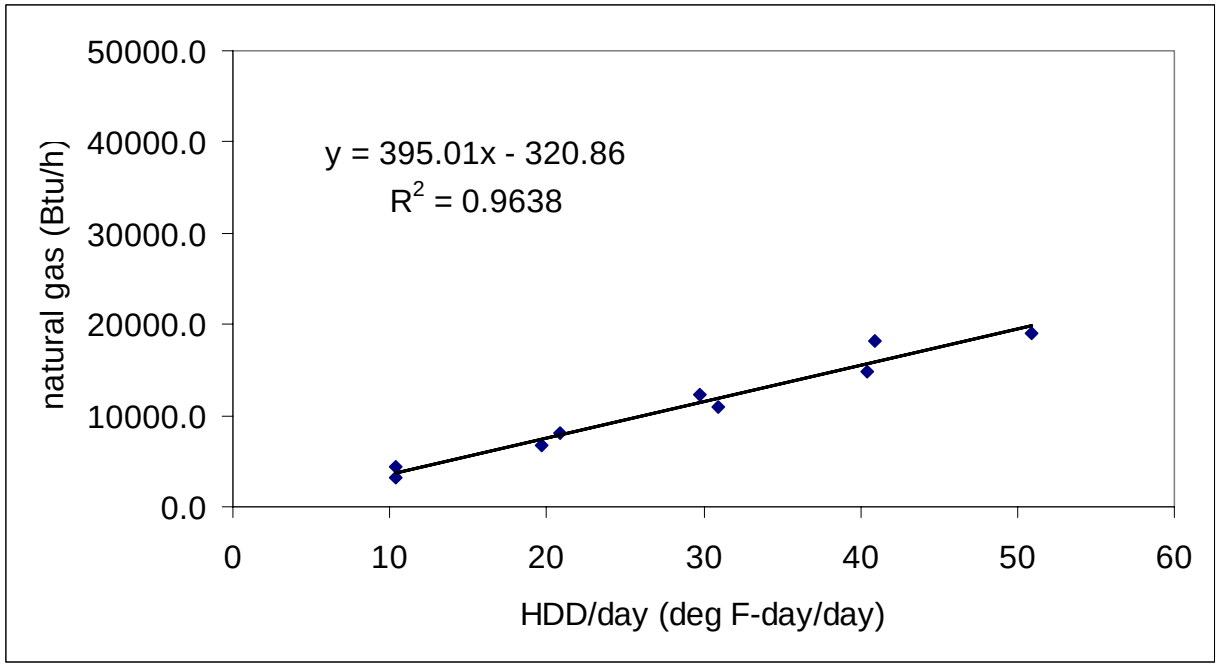


Figure D.5. Natural gas versus HDD/day for a one-year period for Home A-5 (split-level).

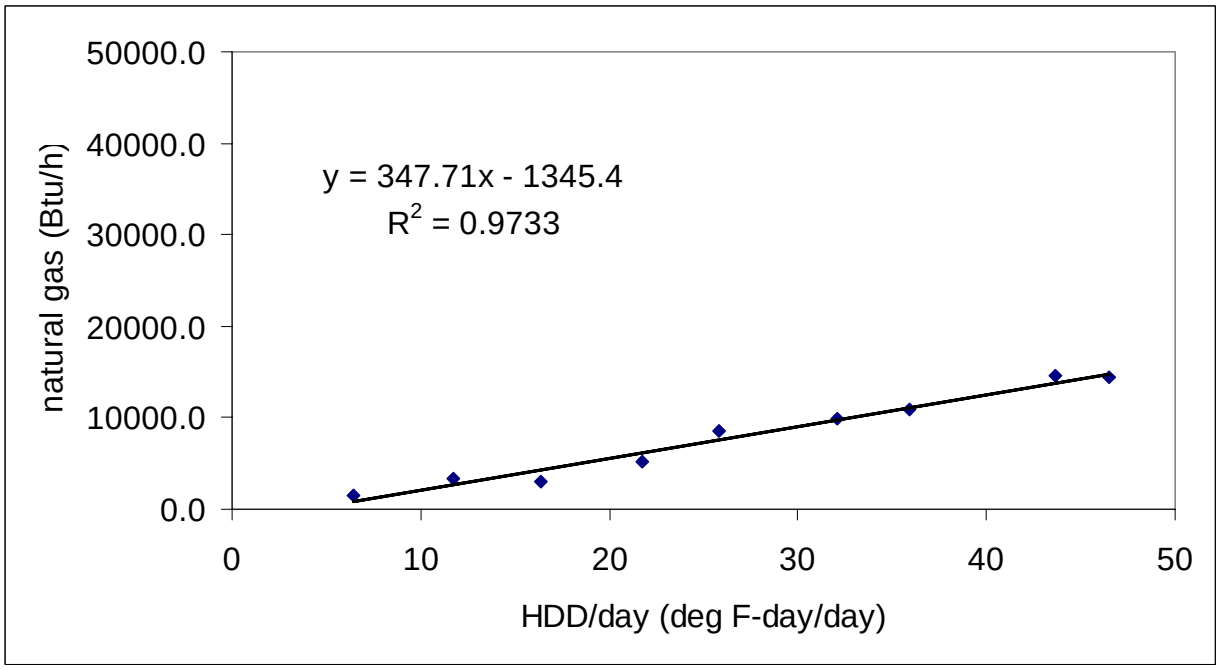


Figure D.6. Natural gas versus HDD/day for a one-year period for Home A-6 (ranch).

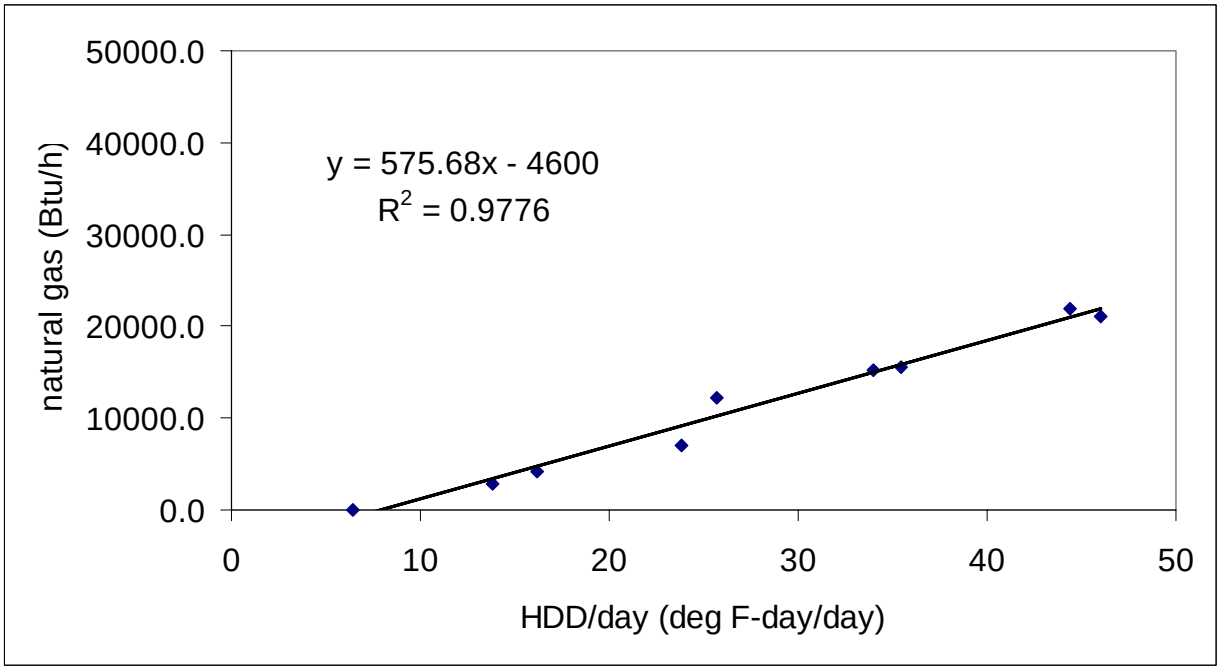


Figure D.7. Natural gas versus HDD/day for a one-year period for Home A-7 (ranch).

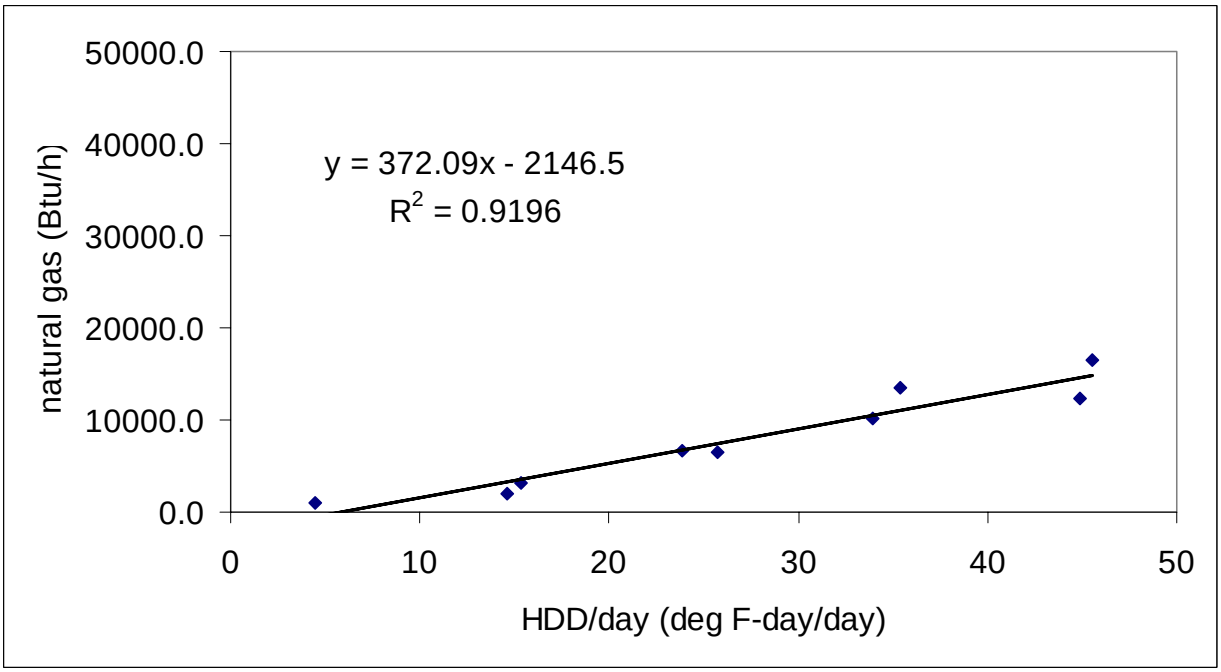


Figure D.8. Natural gas versus HDD/day for a one-year period for Home A-8 (split-level).

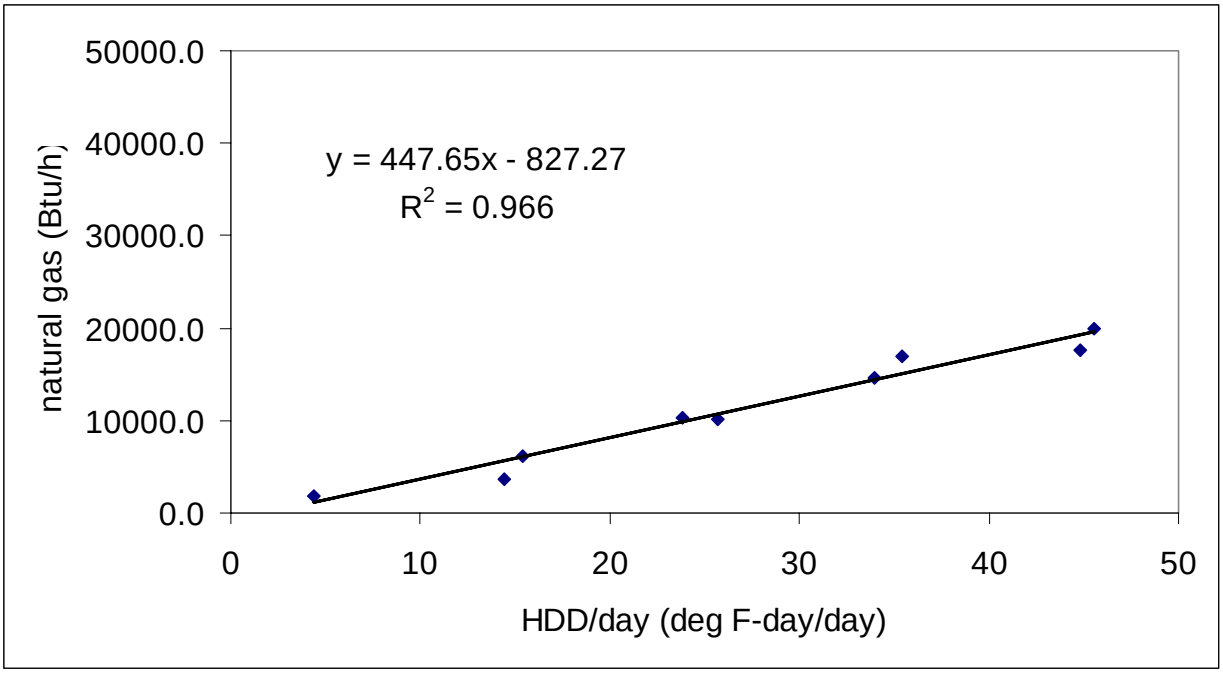


Figure D.9. Natural gas versus HDD/day for a one-year period for Home A-9 (ranch).

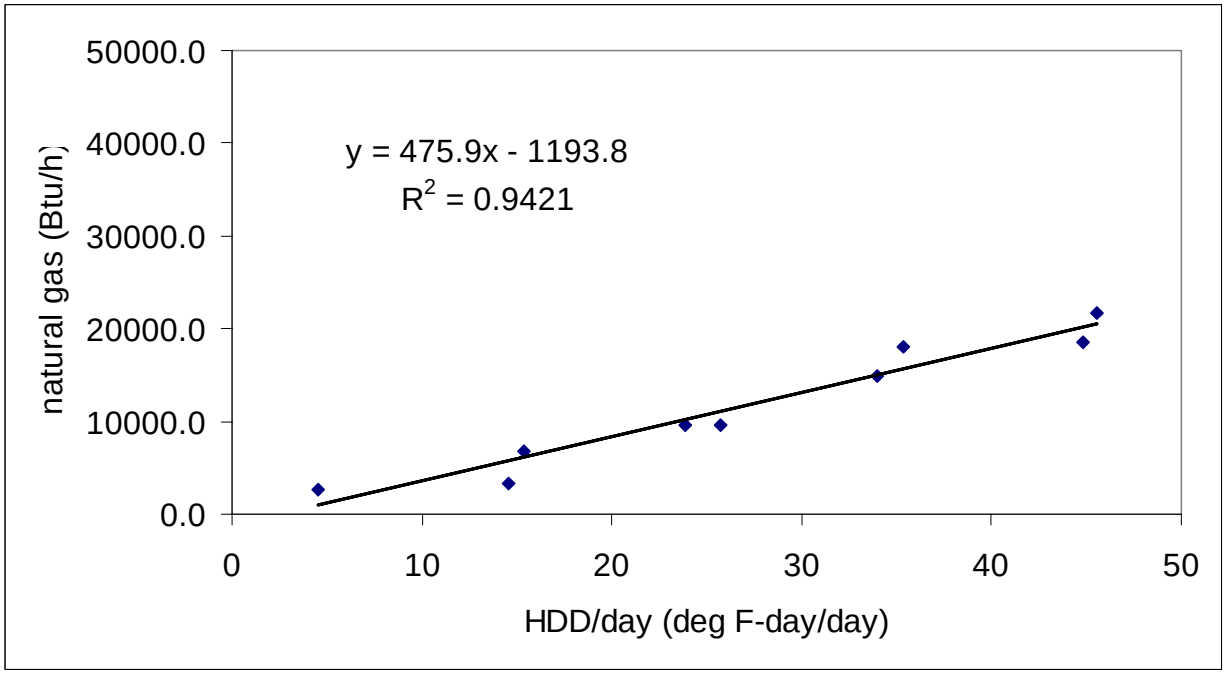


Figure D.10. Natural gas versus HDD/day for a one-year period for Home A-10 (1-1/2 story).

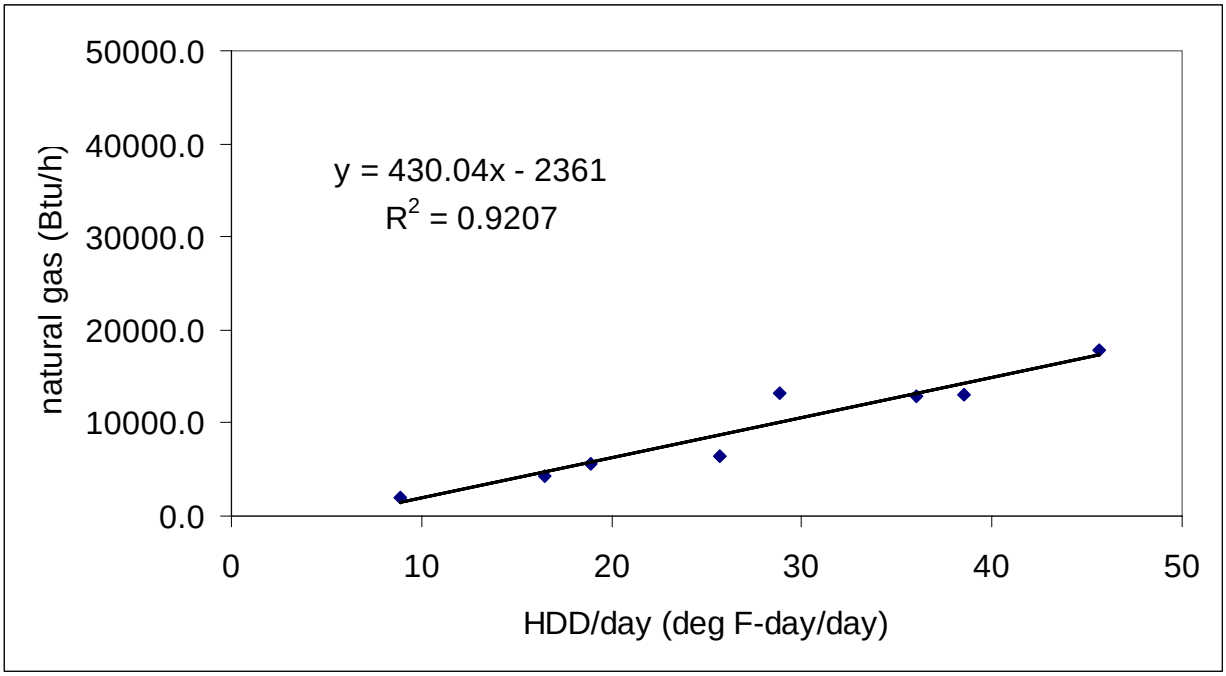


Figure D.11. Natural gas versus HDD/day for a one-year period for Home B-1 (ranch).

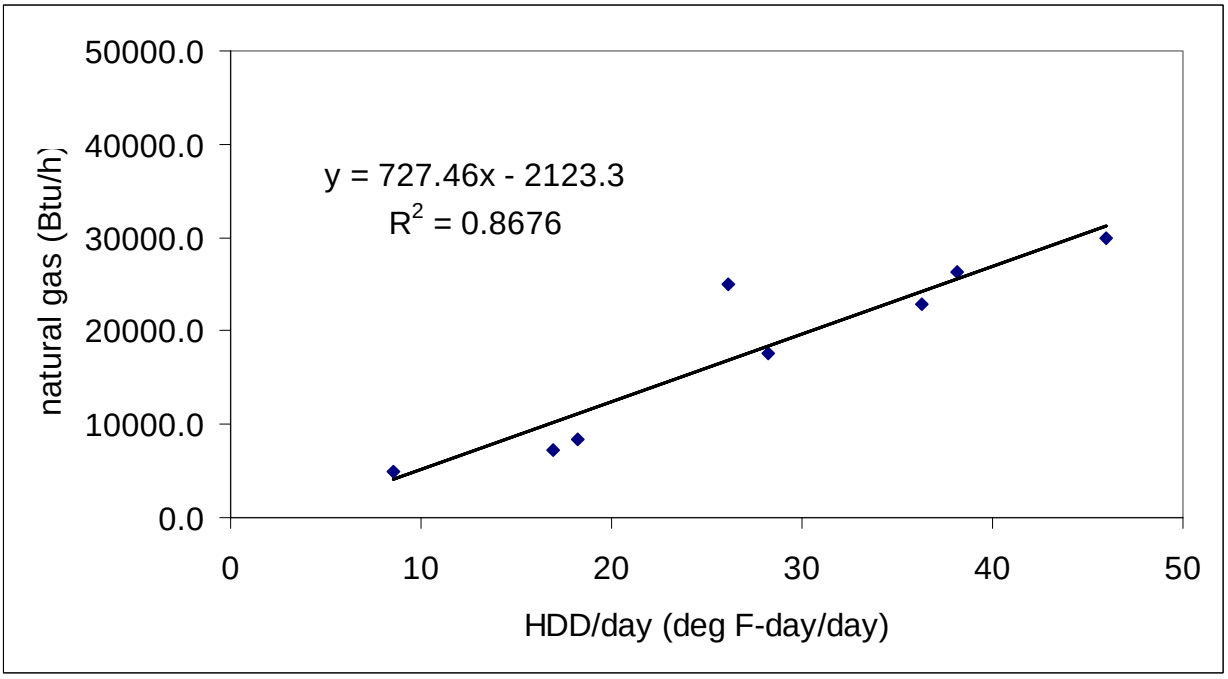


Figure D.12. Natural gas versus HDD/day for a one-year period for Home B-2 (1-1/2 story).

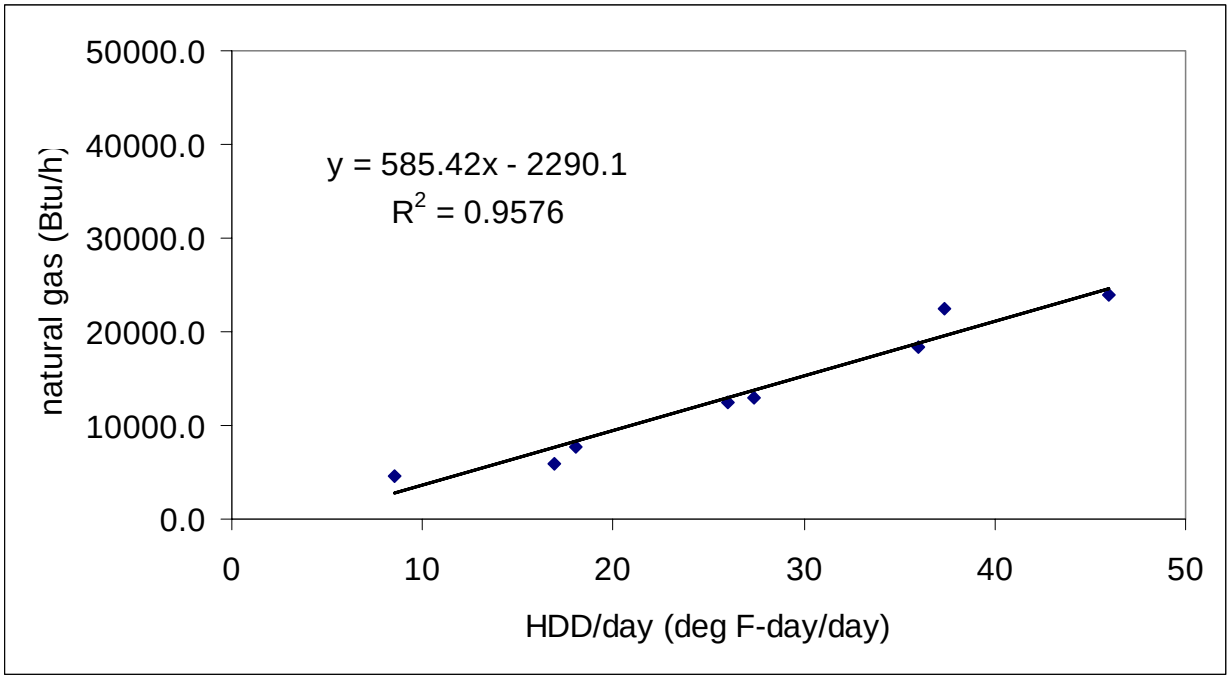


Figure D.13. Natural gas versus HDD/day for a one-year period for Home B-3 (ranch).

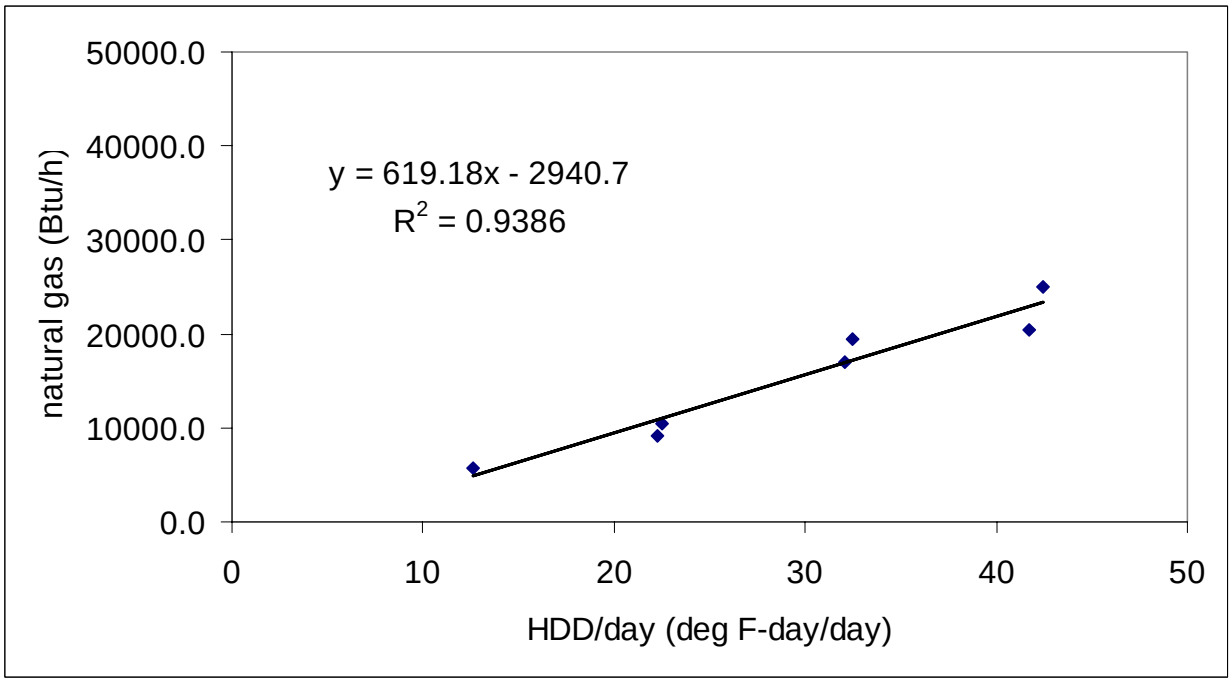


Figure D.14. Natural gas versus HDD/day for a one-year period for Home B-4 (2-story).

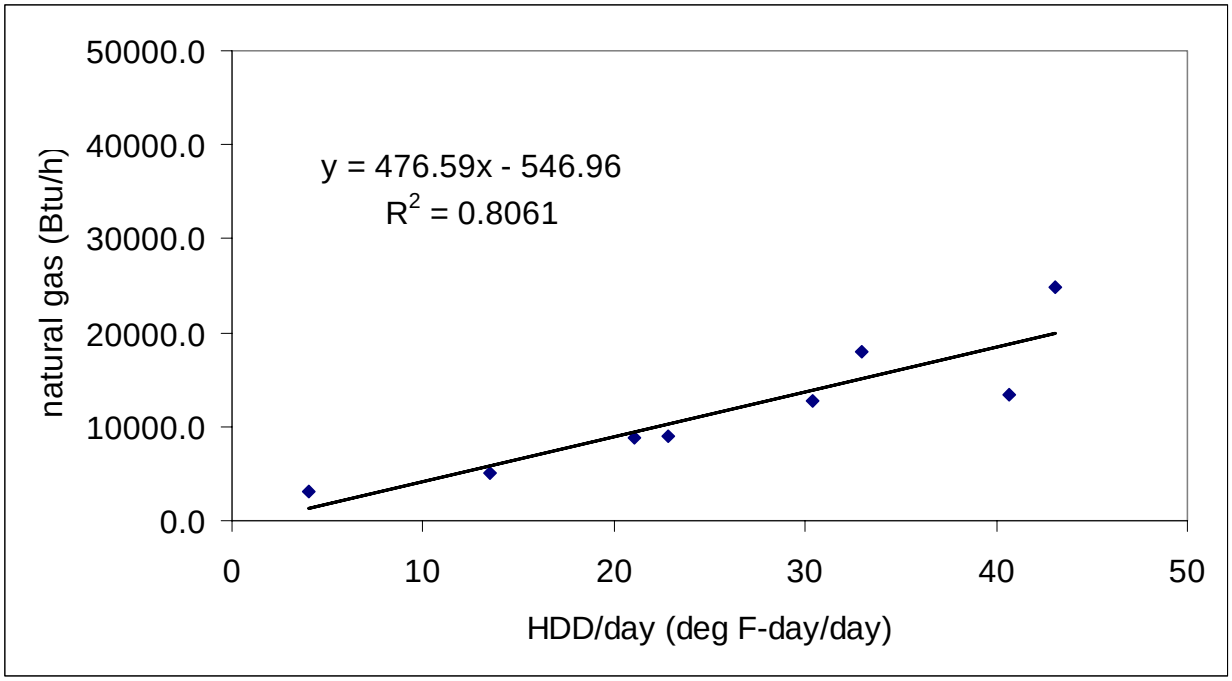


Figure D.15. Natural gas versus HDD/day for a one-year period for Home B-5 (2-story).

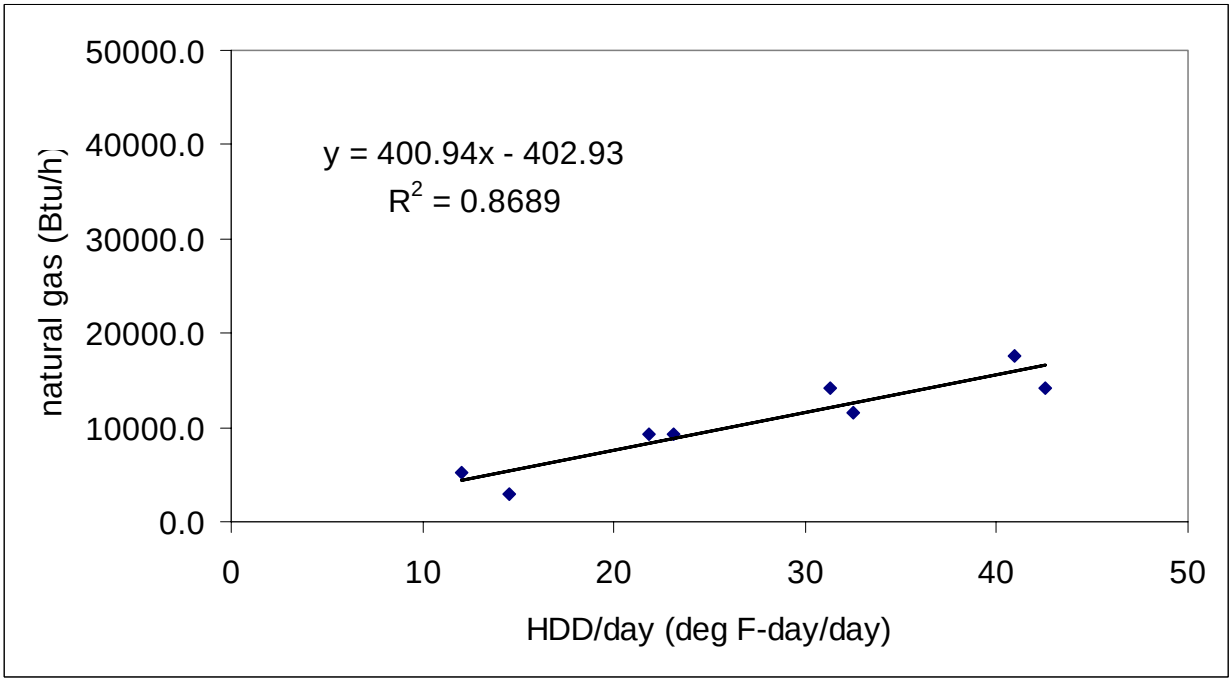


Figure D.16. Natural gas versus HDD/day for a one-year period for Home B-6 (ranch).

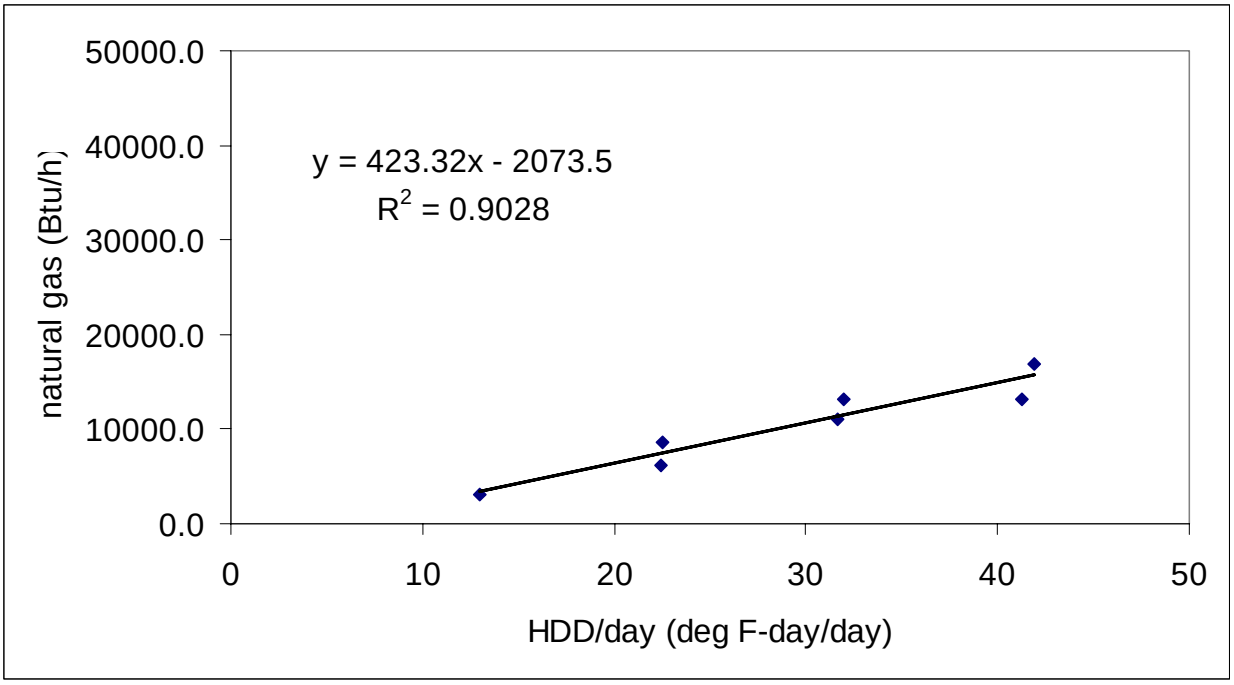


Figure D.17. Natural gas versus HDD/day for a one-year period for Home B-7 (split-level).

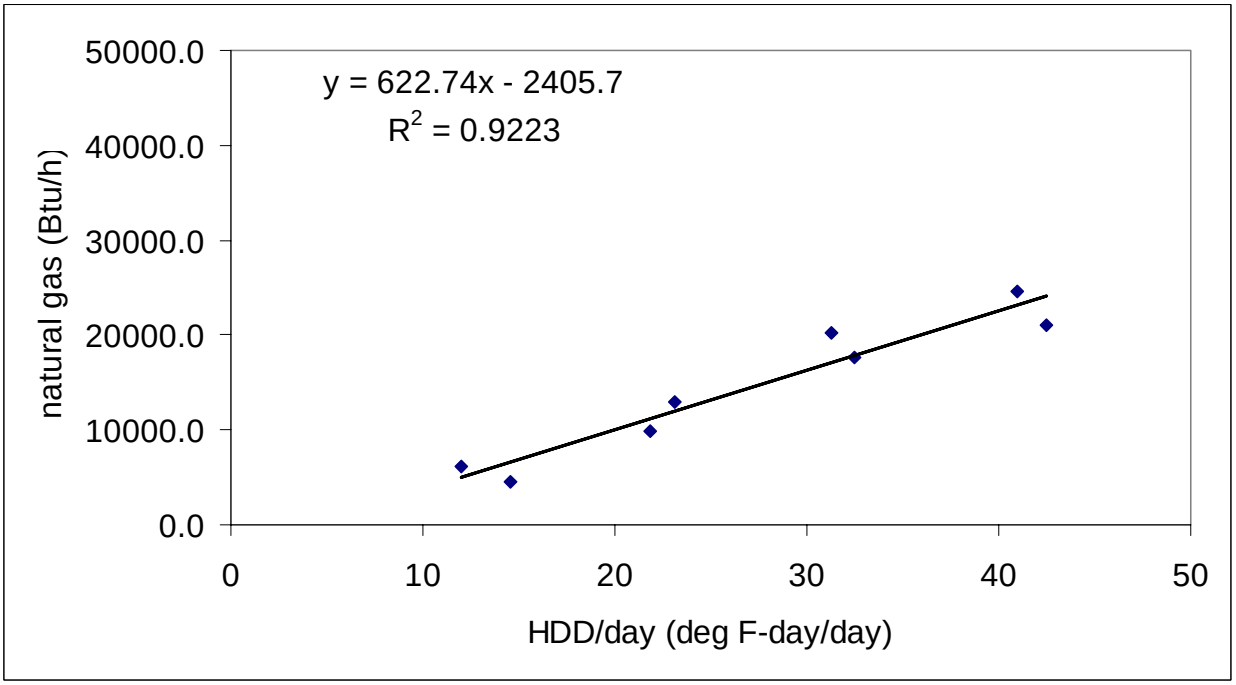


Figure D.18. Natural gas versus HDD/day for a one-year period for Home B-8 (ranch).

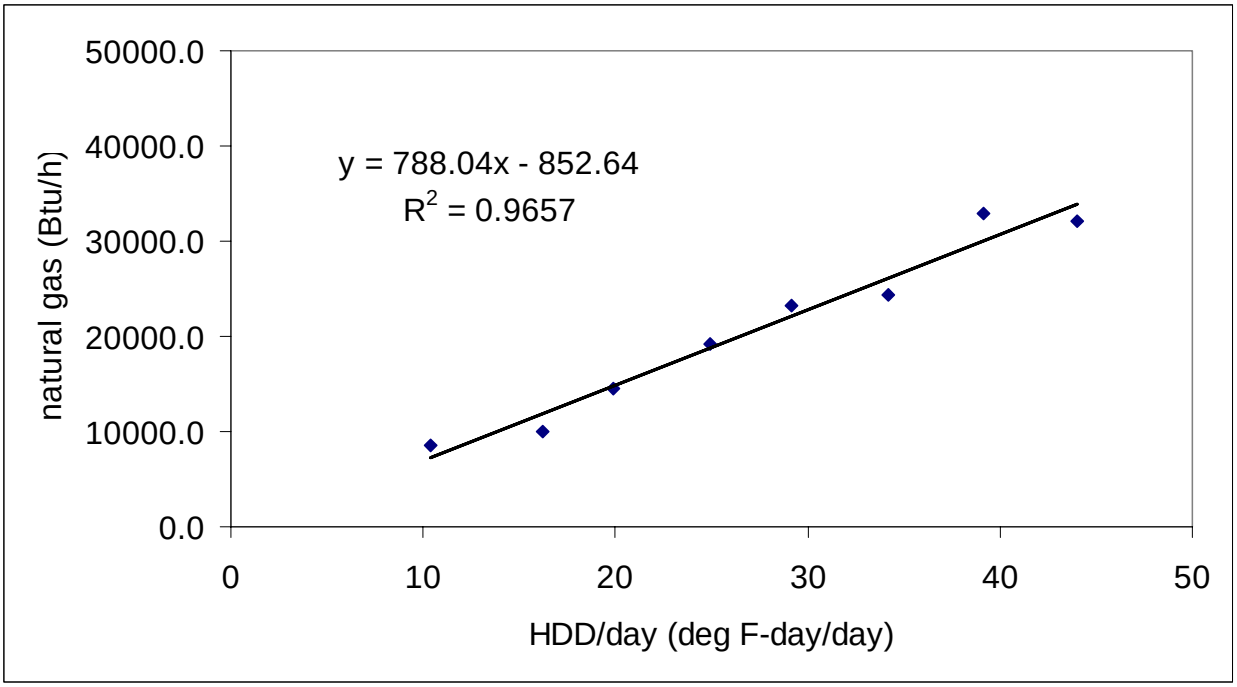


Figure D.19. Natural gas versus HDD/day for a one-year period for Home B-9 (2-story).

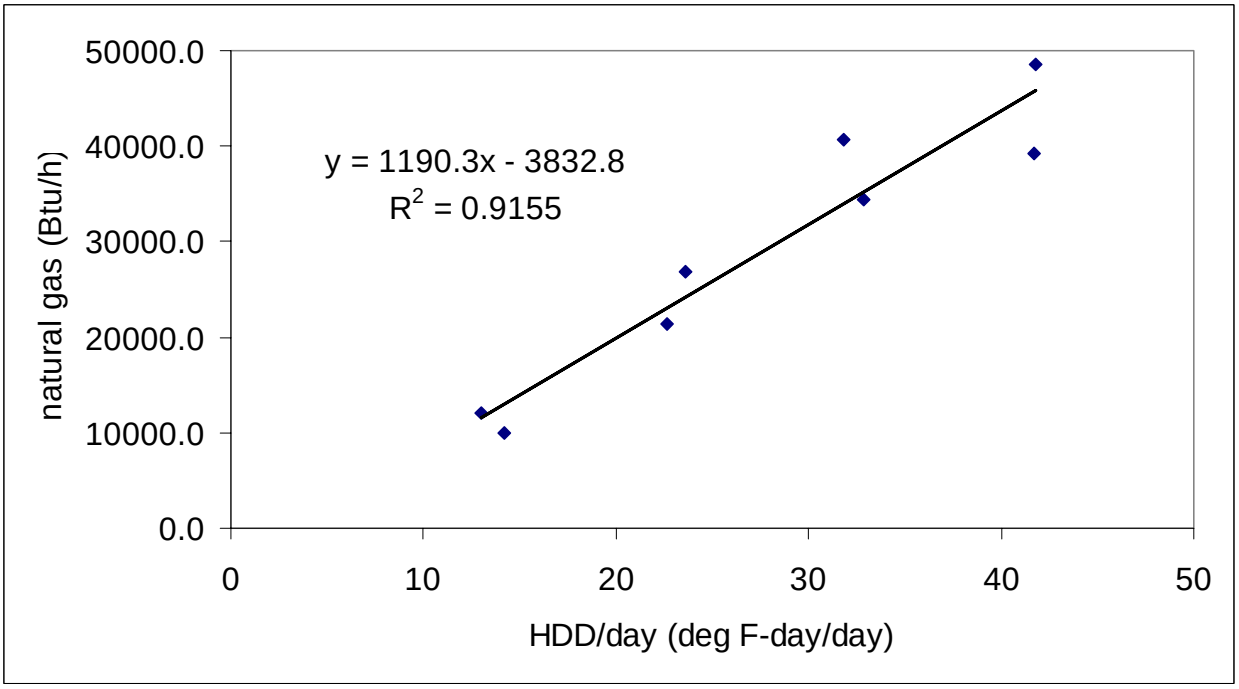


Figure D.20. Natural gas versus HDD/day for a one-year period for Home B-10 (1-1/2 story).

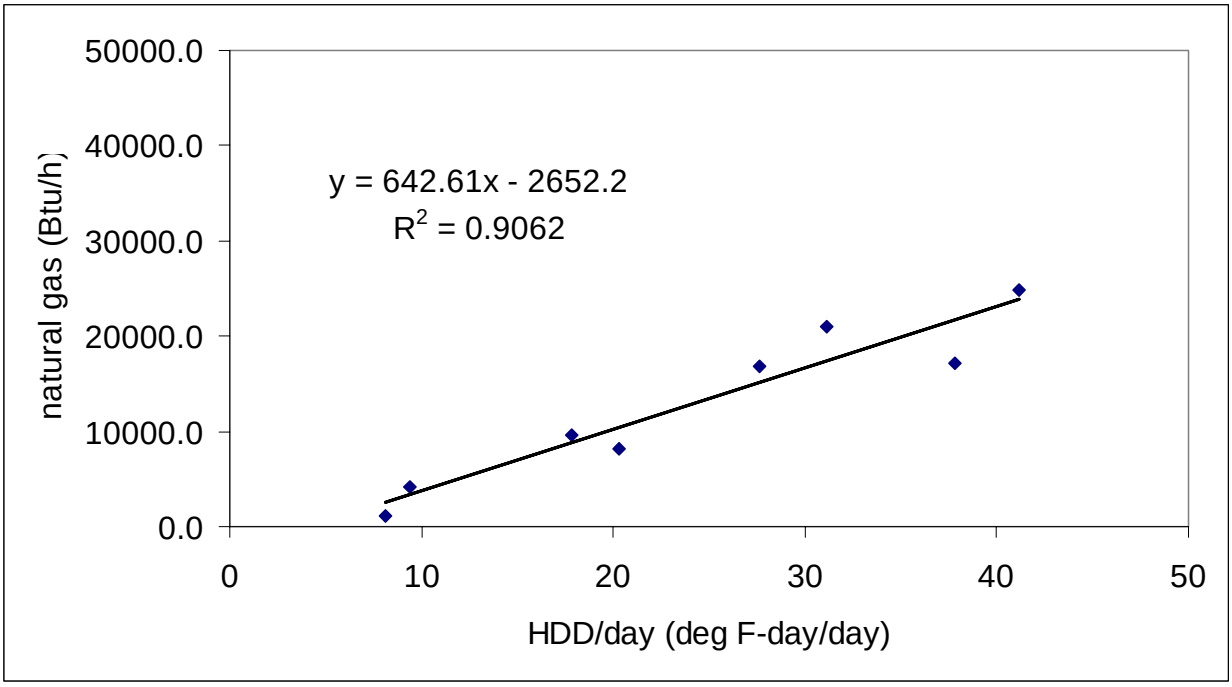


Figure D.21. Natural gas versus HDD/day for a one-year period for Home C-1 (2-story).

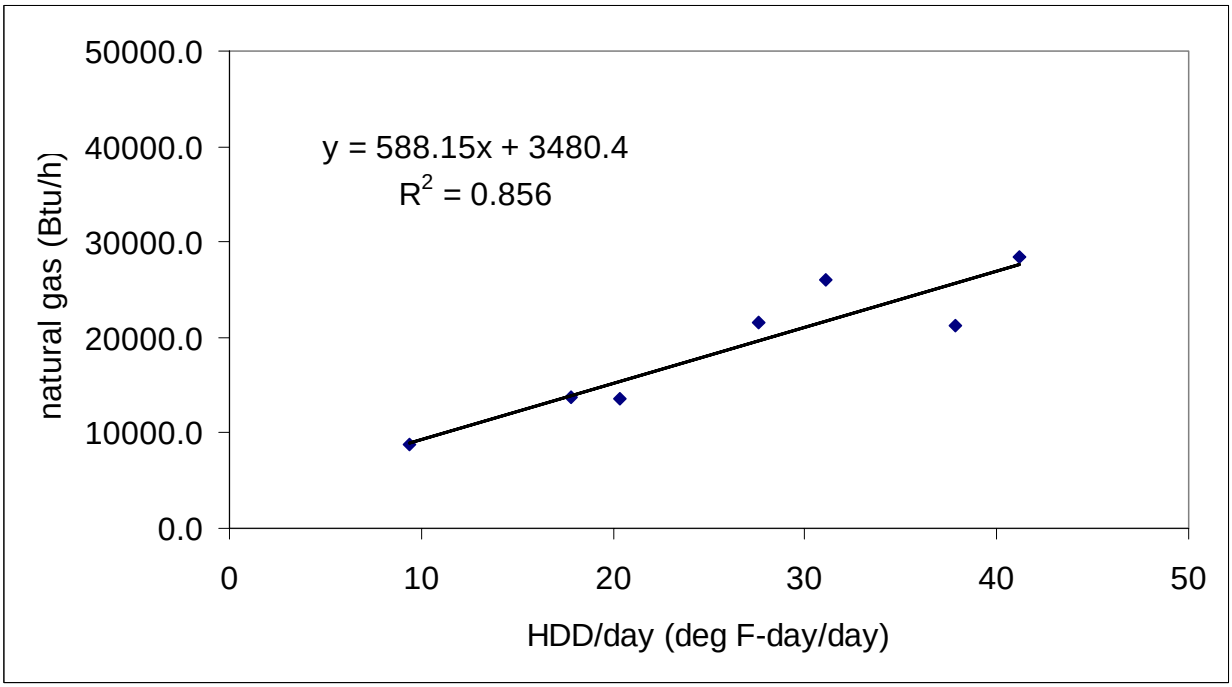


Figure D.22. Natural gas versus HDD/day for a one-year period for Home C-2 (ranch).

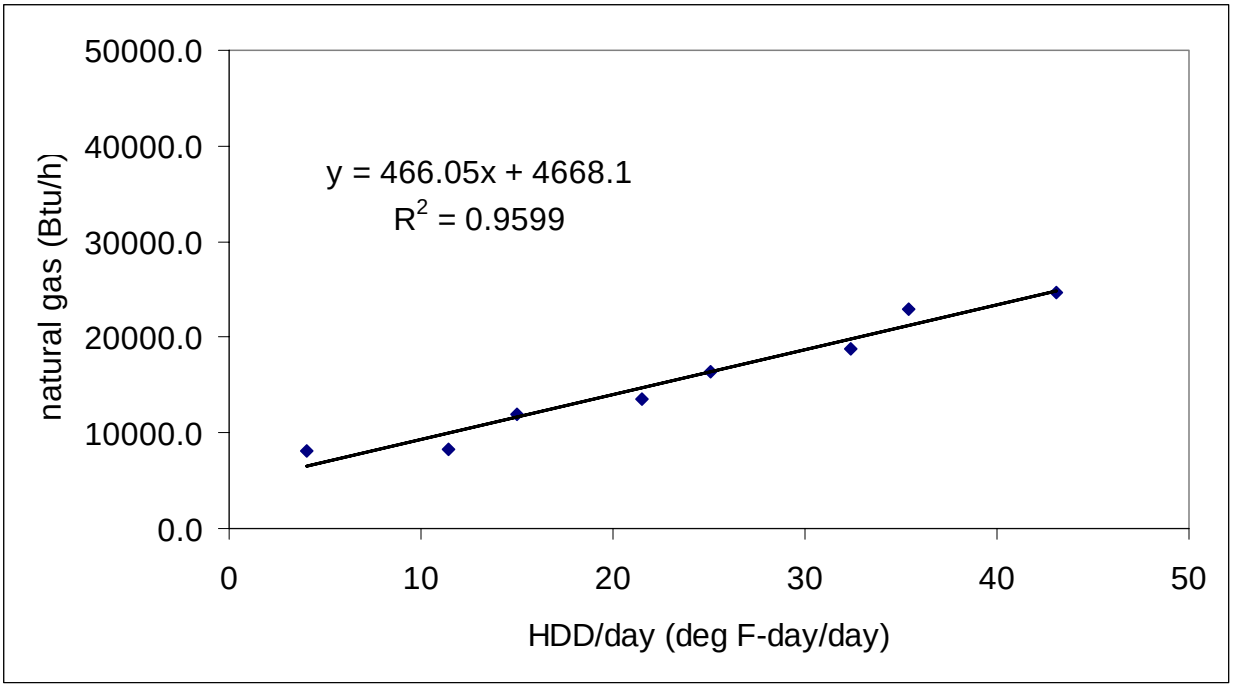


Figure D.23. Natural gas versus HDD/day for a one-year period for Home C-3 (ranch).

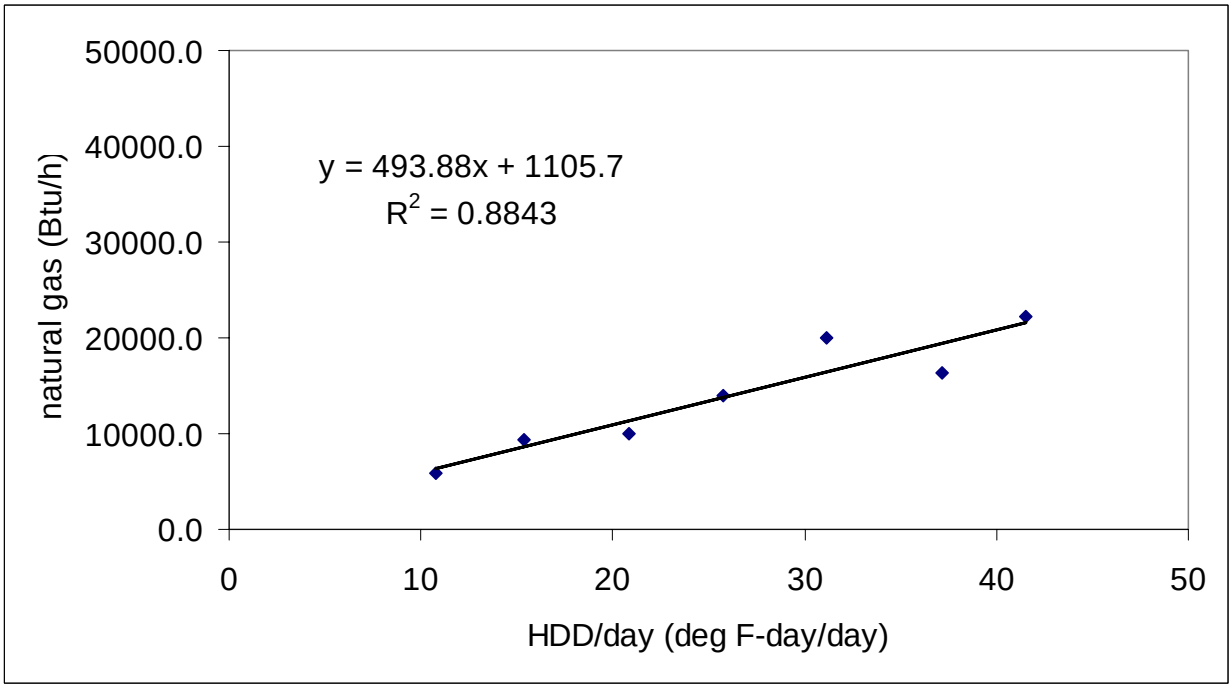


Figure D.24. Natural gas versus HDD/day for a one-year period for Home C-4 (ranch).

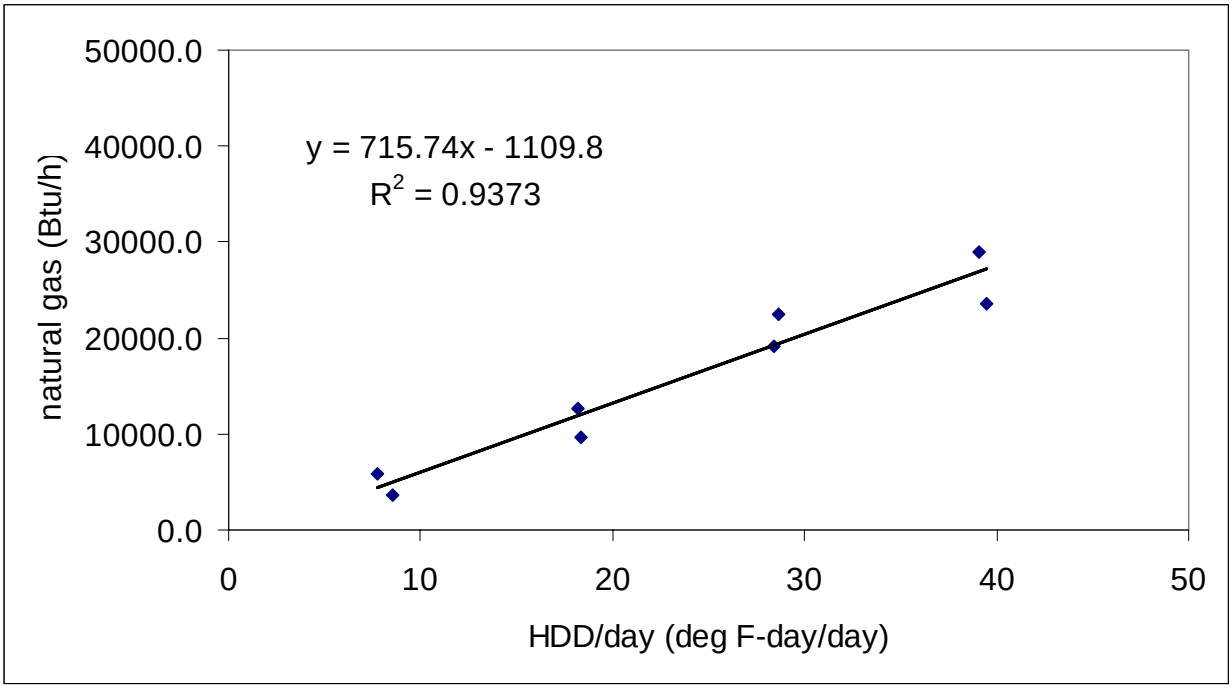


Figure D.25. Natural gas versus HDD/day for a one-year period for Home C-5 (2-story).

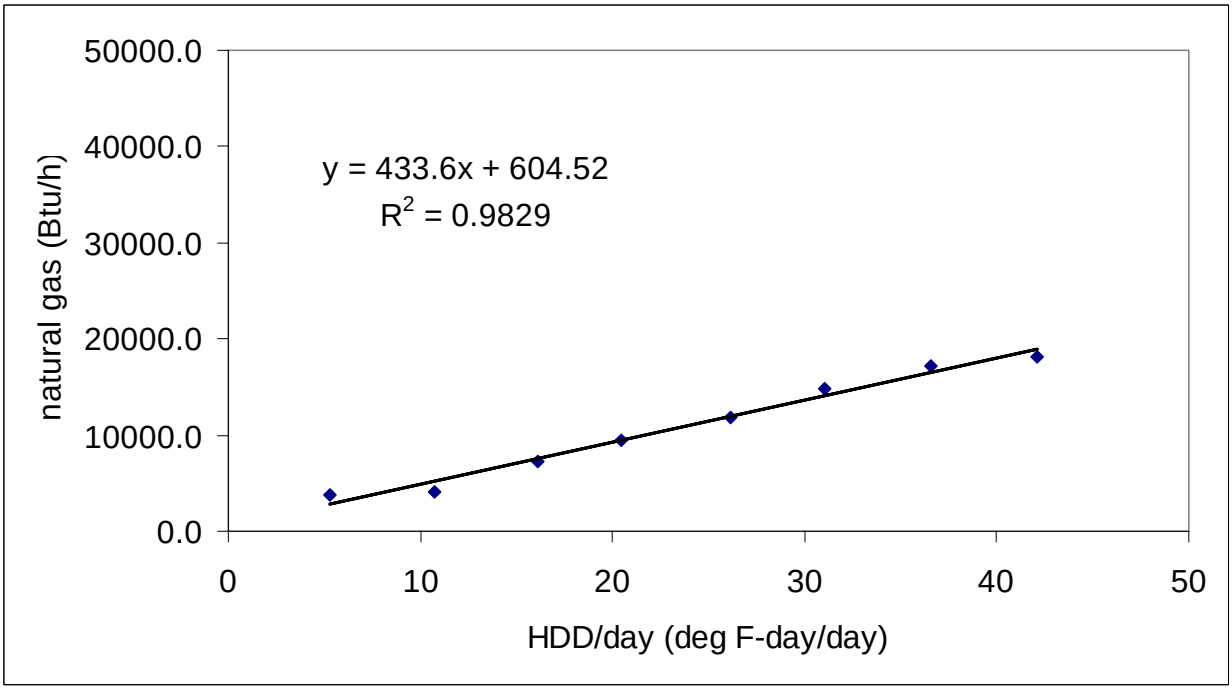


Figure D.26. Natural gas versus HDD/day for a one-year period for Home C-6 (2-story).

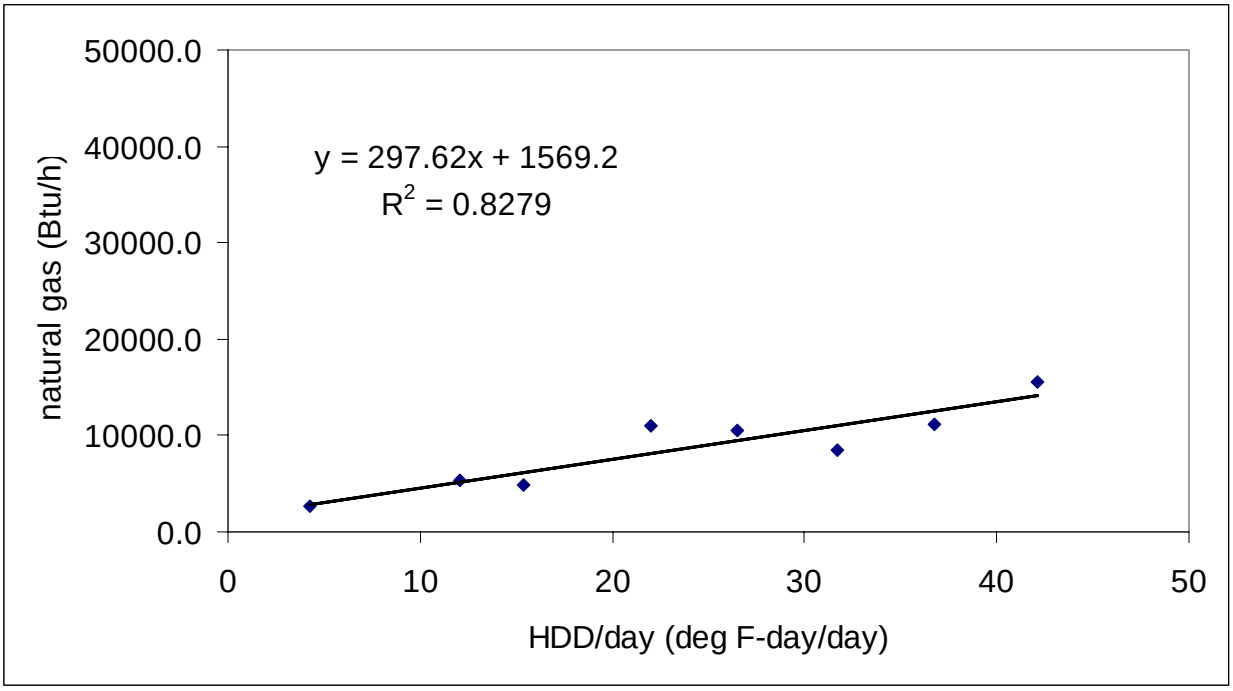


Figure D.27. Natural gas versus HDD/day for a one-year period for Home C-7 (ranch).

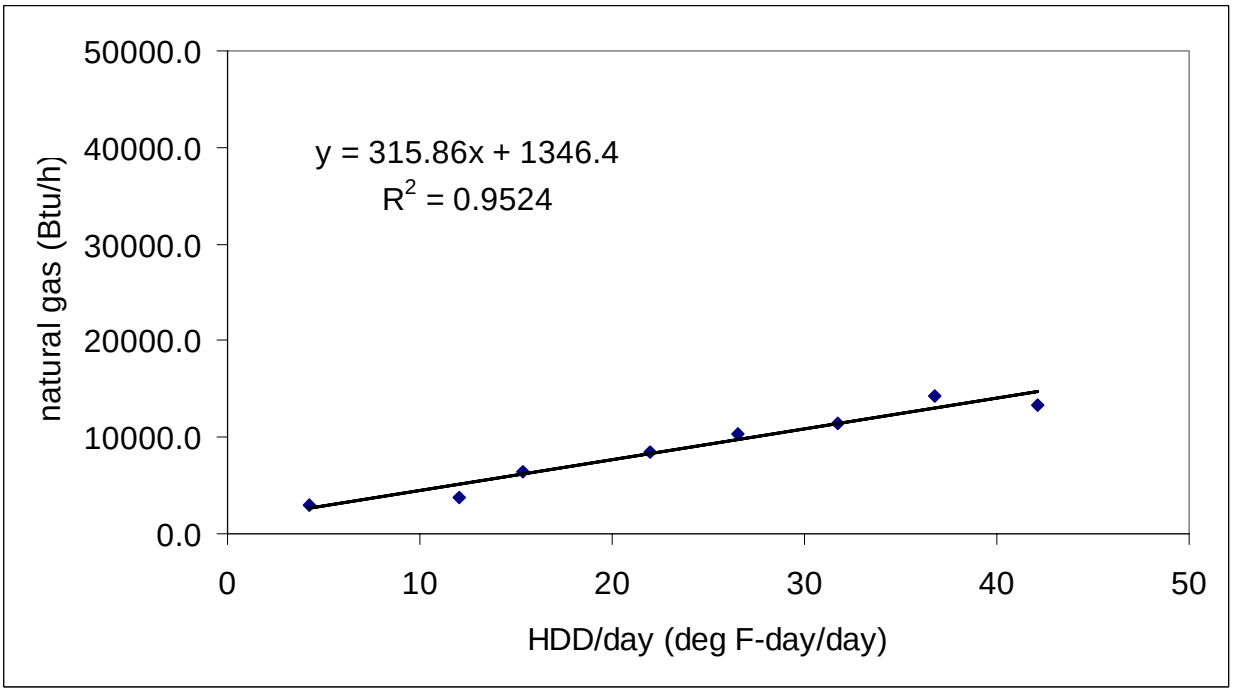


Figure D.28. Natural gas versus HDD/day for a one-year period for Home C-8 (ranch).

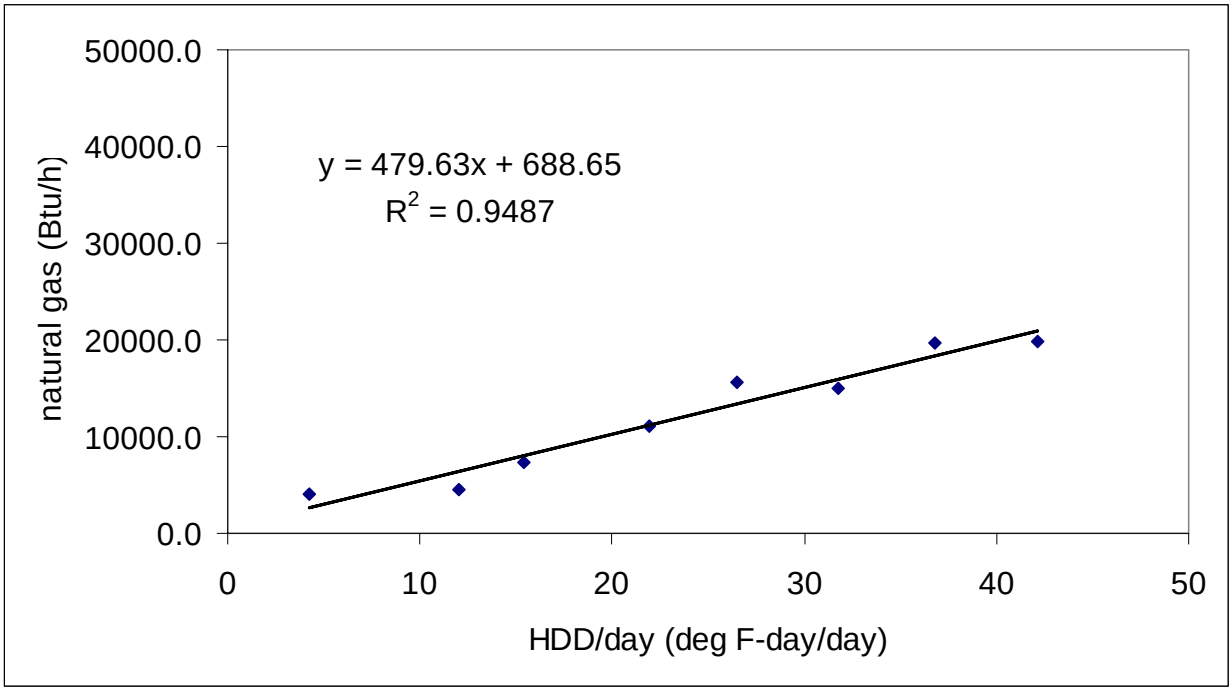


Figure D.29. Natural gas versus HDD/day for a one-year period for Home C-9 (ranch).

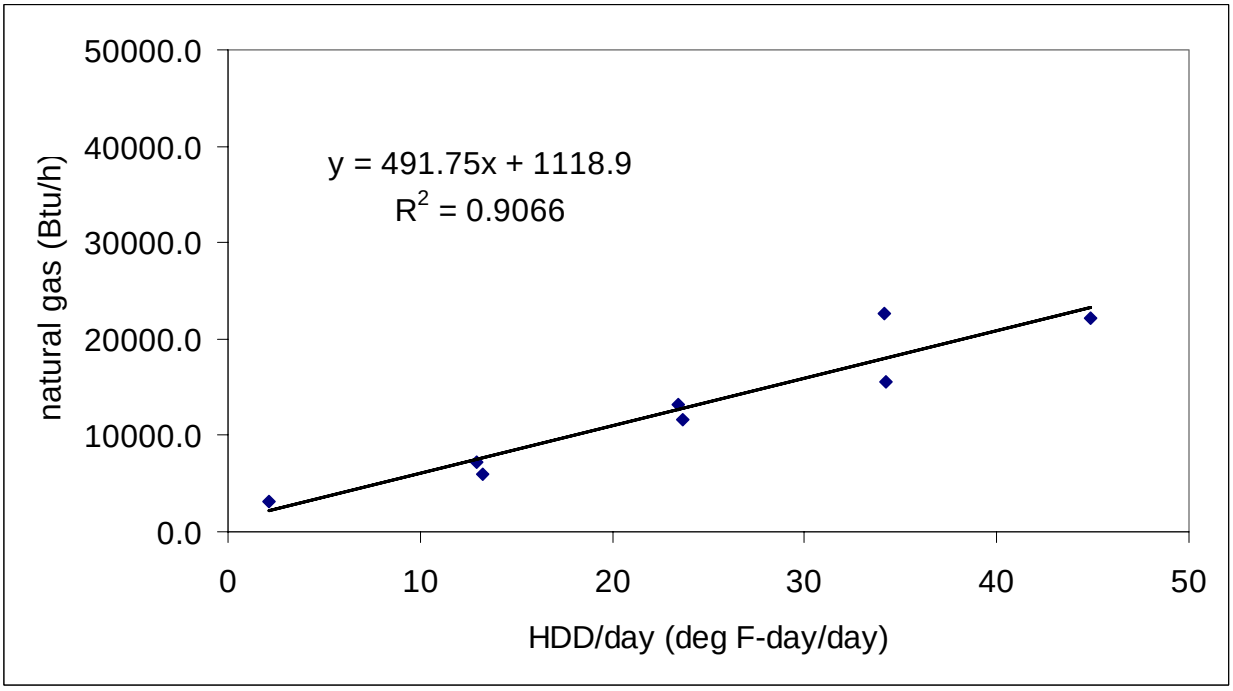


Figure D.30. Natural gas versus HDD/day for a one-year period for Home C-10 (2-story).

Appendix E. Identification of Selected Homes and Energy Acquisition Forms

E.1 Solicitation of Homeowner Names

Since a total of 30 homes throughout Iowa were needed for this study, a letter describing the purpose of this study and how this study was to be performed was sent to every County Engineer in Iowa (refer to Example E.1). The letter asks the engineer for a list of up to five homeowner's names and addresses, within the county that may be interested in participating in this study. The letter also asks the County Engineer to send the list of names and addresses by a certain deadline. The deadline was typically two weeks after the letter was sent. The reason a deadline was specified on the letter was so the County Engineer would respond to the letter quickly rather than putting it off and forgetting about it later. A copy of the homeowner survey was also included with the letter. The purpose of the study was explained to the County Engineer so that he or she knows what would be expected of the homeowner. In addition, a copy of the homeowner survey was sent so that the County Engineer could see that the homeowner survey was short, simple, and not time consuming for the homeowners to complete.

There are three main reasons why this letter was sent to all the County Engineers. The first reason is that they may know of homeowners within their county, such as friends, relatives, and co-workers, which may be interested in participating in this study. The second reason is that they may be able to provide additional contacts that in turn may provide names and addresses of homeowners. The third reason is that the County Engineer personally may be interested in participating in this study.

Even though numerous names and addresses of potentially interested homeowners were obtained from the County Engineers, more names and addresses were needed for the study. Because of this shortage of potential participants, a letter similar to the original letter previously sent to the County Engineers was also sent to County Officials and City Officials in regions of Iowa where more homeowner participation was needed. Also, many students at Iowa State University (ISU) were asked to provide names and addresses of any homeowners that they thought might be interested in participating in the study.

Between the County Engineers, County Official, City Officials, and students at ISU, a total of 132 names and addresses of potentially interested homeowners were obtained.

E.2 Letter to the Homeowner

A letter was sent to all of the homeowners (refer to Example E.2) that were referred by the County Engineers, County Officials, City Officials, and ISU students. The letter informed the homeowners about the purpose of the study and how they would be involved in the study, if they were interested in participating. The letter also informed the homeowners about how they could benefit from the study if they participated. A homeowner survey (refer to Example E.3) along with a pre-addressed and stamped envelope was sent with the homeowner letter. The letter asked the homeowner to fill out the homeowner survey and to mail the survey in the pre-addressed envelope if he/she was interested in participating in the study.

Out of the 132 letters sent to the potentially interested homeowners, at least 70 homeowners filled out the survey and returned it by mail.

E.3 Homeowner Survey

The completed homeowner surveys were used to identify those homes that were considered to be desirable candidates for the study. Because the survey provided a key role in the study, considerable thought and effort went into its development. The homeowner survey was kept relatively short to minimize the time required of the homeowner. The homeowner survey was expected to take the homeowner only about five minutes to fill out. In addition, the questions asked on the homeowner survey were kept simple to answer since difficult questions might discourage the homeowner from responding to the questions on the homeowner survey. The homeowner survey contained twelve questions that allowed the project investigators to determine the general trends of the typical single-family home in Iowa and to identify those homes that were most desirable for the study (refer to Example E.3).

E.4 Selection Process

After the completed Homeowner Survey forms were returned to the project investigators, the forms were reviewed for potentially acceptable homes to audit. The homeowners with homes that seemed most fit for the study were sent an acceptance letter. The acceptance letter thanked the homeowner for completing and returning the Homeowner Survey, informed the homeowner that their home met the criteria for the study, and stated that the person conducting the walk-through energy audit would contact the homeowner in a few days to arrange a time and day to perform a walk-through energy audit of their home and to answer any of their questions. In addition, the acceptance letter informed the homeowner about the areas of the home and subjects that the auditor would inspect, and provided the homeowner with contact information for the auditor.

The homeowners were contacted by phone about a week after the acceptance letter was sent, based on the assumption that it would take about 3 to 4 days for the homeowners to receive the acceptance letter. When the homeowners were contacted, they were asked if they had the opportunity to read the letter. If the homeowners did not receive the letter or had not read the letter, then the auditor explained the purpose of the letter and what the walk-through energy audit entailed to the homeowners. In general, it was found that if the homeowners were contacted more than two weeks after the acceptance letter was sent then most homeowners had forgotten about the contents of the acceptance letter. During the conversation, the homeowners were informed that their energy related information would need to be obtained from their utility companies, and that the auditor would bring a release form for their signature when the auditor arrived at their homes for the walk-through energy audit. Then, the auditor asked the homeowners if they had any questions about the walk-through energy audit and scheduled a time and day for the energy audit with the homeowners.

To minimize the amount of traveling required, anywhere from three to seven acceptance letters where sent at any one time to homes that were relatively close to each other. For example:

homes in the Cedar Rapids area that potentially met the requirements for the study were sent an acceptance letter at the same time.

Initially, eleven homes that were less than 20 years old were selected for the study, regardless of the type of heating fuel that they used. Five of these homes were located in the Cedar Rapids area and six were located in western Iowa. Out of these eleven homes, three used natural gas, four used propane, and four used electricity (heat pumps) for heating the home during the winter. A walk-through energy audit was performed on each of these homes and the energy related information for each of these homes was obtained. After reviewing the energy related information for these eleven homes, it was found that some of the data could not be used in the analysis. One home was about two years old, but had less than two years worth of energy related information required.

The energy related information from the 4 homes that used propane for heating could not be used because the amount of propane used was not metered on a monthly basis. A home that uses propane has a tank filled located outside of the home which is filled when the propane level is low or when propane prices are low. Because of this, it was not possible to determine the amount of propane used on a monthly basis.

The homes that used electricity to run their heat pumps were metered on a monthly basis, but the data from the utility bills for two of the homes could not be used. In these two cases, the electricity used for the heat pump was metered separately from the electricity used for the rest of the home during the fall, winter, and spring months, and the electricity used for the heat pump and the rest of the home were combined together during the summer months. As a result, these two homes each had three electrical meters installed with one meter for the heat pump, one meter for the rest of the home, and one meter that combined the total electrical usage of both the heat pump and the rest of the home together. The reason that the electricity for the heat pump is separated from the electricity for the rest of the home during the summer is because the homeowners receive a discounted electrical rate for their heat pumps during the fall, winter, and spring months.

Because of potential difficulties comparing homes that use propane or electrical heating, it was decided to only use homes with natural gas heating between two to twenty years of age for the study. Homes that use natural gas heating have all of their energy usages, such as natural gas and electricity, metered on a monthly basis. Homes less than two years old would not be able to provide enough energy related information required, while homes that were greater than twenty years old may not meet any of the requirements of either the 1992 MEC or the 2000 IECC. When contacting the homeowners with homes that were two to three years old, they were asked how long they had lived in their home in order to ensure that they could provide enough energy related data.

E.5 Energy Audit Authorization Form

Prior to performing the walk-through energy audit of each home, the homeowner was asked to fill out an energy audit authorization form. The purpose of the authorization form was to obtain the homeowner's permission, allowing the ISU research team to perform the walk-through

energy audit during a certain time period on a certain date. Also, by signing the form, the homeowner acknowledged that he/she understood the purpose of the study and was willing to participate in the study.

Several utility companies were contacted for information about what they thought should be required in an energy audit authorization form. The purpose of the study and what was required for the study was explained to each utility company that was contacted. However, from conversations with each of the utility companies, it was found that none of them had ever used an authorization form prior to conducting an energy audit of a home. Therefore, an energy audit authorization form was developed as part of this study (refer to Example E.4).

E.6 Energy Bill Release Form

Prior to performing the walk-through energy audit, the homeowner was asked to sign and date an energy bill release form. The purpose of the energy bill release form was to acquire energy related information for the years 2002 and 2003 from the homeowner's utility company. By signing the release form, the homeowner acknowledged that he/she understood that their utility company would release energy related information for this study. The homeowner also acknowledged that the energy related information would not be released to other parties and that it would be kept confidential.

Prior to making the energy bill release form, a few utility companies were contacted to find out what information would be necessary on the form so that the utility company would release the energy related information. The energy bill release form developed as part of this study is denoted as Example E.5.

E.7 Energy Audit Form

In order to compare the physical characteristics of each home, a walk-through energy audit was performed for each home within the study. To record the physical characteristics of each home, an energy audit form was developed (refer to Example E.6). The purpose of the energy audit form was to determine the general characteristics of each home that was used in the study and to explain any abnormalities that might occur when comparing energy related data between homes. The energy audit form was written in an organized manner such that it would allow for a timely and efficient walk-through energy audit. In most cases, the walk-through energy audit took less than one hour to complete.

E.8 Homeowner Education

The purpose of this study was not only to determine if it is economically feasible for the state of Iowa to adopt the 2000 IECC, but it was also used to help educate homeowners about how to make their homes more energy efficient and to promote energy conservation. Questions asked by the homeowner about making their home more energy efficient was answered by the auditor to the best of his ability. The homeowner was given an information packet written by the Iowa DNR called "Energy Savers" that contains tips on saving energy and money at home. The Energy Savers packet[2] contains tips on saving energy and many interesting facts. The major topics listed in the Energy Savers packet are:

- Insulation and Weatherization
- Heating and Cooling
- Water Heating
- Windows
- Landscaping
- Lighting
- Appliances

[2] U.S. Department of Energy, 2002, Energy Savers: Tips on Saving Energy and Money at Home (brochure; also available at <http://www.eren.doe.gov/consumerinfo/energy_savers>).

Example E.1. Letter to County Engineer

(County Engineer Name)
(Address)

Dear (Recipient name):

I am writing to you on the recommendation of Michael Adams, Program Planner for the Iowa Department of Natural Resources (DNR). I am part of a research team at Iowa State University (ISU) that is conducting a study to address building code standards. Mr. Adams recommended you as an agent that would be interested in both the results of the study and residential energy consumption in your county.

The Iowa State University research team, comprising of Dr. Michael Pate, Dr. Francine Battaglia and myself, will investigate the benefits of upgrading building codes in Iowa. The study is part of an initiative by the Iowa DNR under the direction of Mr. Adams. The objective of the study is to compare energy consumption and incremental building costs for single-family residential homes. In particular, homes in various regions within Iowa that were built according to building codes such as the 2000 International Energy Conservation Code (2000 IECC), the 1992 Model Energy Code (92 MEC), and lessor codes.

In our study, a number of homes in Iowa will be identified as potential homes for participation. Initially, homeowners will complete a short survey, enclosed herein, so that the ISU research team can determine whether or not a home is a suitable model for the study. In particular, the study will focus on homes built within the last 20 years.

The owners of the homes chosen for the study will be asked to give written permission to allow the ISU research team to do an energy audit of the home, in the company and at the convenience of the homeowner. This audit is expected to last less than one hour. Also, with the permission of the homeowner, the ISU research team will obtain energy consumption information for a one year period from the utility companies. This information will be kept confidential within the research project.

I would appreciate it if you would provide a list of 1 to 5 homeowners (names and addresses) within your county that might be interested in participating in the study. Each homeowner will receive a letter describing the study and benefits to them if they participate. If possible, please send a short list of names to me by May 15th.

If you have any questions, please contact one of us from the ISU research team or Michael Adams of the Iowa Department of Natural Resources. On behalf of the team, thank you in advance for your time and consideration.

Sincerely,

Jeremy Cloutier

Jeremy Cloutier, Research Assistant

Example E.2. Letter to Homeowners

(Homeowner)
(Address)

Dear (Recipient name):

I am writing to you on the recommendation of (County Engineer name), County Engineer for Adair. I am part of a research team at Iowa State University (ISU) that is conducting a study to address building code standards. Mr. Kauffman recommended you as a homeowner that may be interested in the results of the study. Your participation would be very minimal, as described below.

The Iowa State University research team, comprising of Dr. Michael Pate, Dr. Francine Battaglia and myself, will investigate the benefits of upgrading building codes in Iowa. The study is part of an initiative by the Iowa DNR under the direction of Mr. Adams, Program Planner for the Iowa Department of Natural Resources. The objective of the study is to compare energy consumption and incremental building costs for single-family residential homes.

In our study, a number of homes in Iowa will be identified as potential homes for participation. Initially, homeowners will complete a short survey, enclosed herein, so that the ISU research team can determine whether or not a home is a suitable model for the study. In particular, the study will focus on homes built within the last 20 years.

The owners of the homes chosen for the study will be asked to give written permission to allow the ISU research team to do an energy audit of the home, in the company and at the convenience of the homeowner. This audit is expected to last less than one hour. Also, with the permission of the homeowner, the ISU research team will obtain energy consumption information for a one year period from the utility companies. This information will be kept confidential within the research project. In return for your participation, the benefits to you will be the receipt of the final results of the study and information on how to reduce your energy bills.

We would greatly appreciate your participation in our study. If you are interested, please fill out the short survey, which should take less than 15 minutes of your time, and mail it back to us. We will contact you within two weeks after receipt of your survey.

If you have any questions, please contact me at (515) 572-7722 or jerclou@iastate.edu. On behalf of the ISU research team, thank you in advance for your time and consideration.

Sincerely,

Jeremy Cloutier

Jeremy Cloutier, Research Assistant

Example E.3. Homeowner Survey

Department of Natural Resources/Iowa State University Energy Project

Homeowner Survey

First Name:_____ Last Name:_____

Address:_____

City:_____ State:_____ ZIP:_____

Phone:_____ Email:_____

1. Approximately how old is your home? _____
2. How many people live in your home? _____
3. What style of home do you own?
   ___Ranch
   ___Split level
   ___2-Story
   ___Other_____
4. Excluding bathrooms and hallways, how many rooms are in your home? _____
5. Do you have a basement?
   ___Yes Is it heated? Yes___ No___
   ___No Is it a crawl space? Yes___ No___
6. Do you have an attic?
   ___Yes Is it insulated? Yes___ No___
   ___No
7. What kind of fuel do you use to heat your home?
   ___Natural Gas
   ___Oil
   ___Electricity
   ___Propane
   ___Wood
   ___Other _____

(over)

8. What is the approximate temperature your thermostat is set to during:

   Winter:

   Daytime_____

   Night-time_____

   Summer:

   Daytime_____

   Night-time_____

9. What kind of windows does your home have?
   ___Single pane
   ___Double pane

10. Which of the following would best describe the conditions of the exterior of your home?
    ___All windows and doors are weather stripped and caulked
    ___Some windows and doors are weather stripped and caulked
    ___No windows and doors are weather stripped and caulked
    ___Caulking and weather-stripping needs replacing

11. With which energy code was your home built in accordance?
    ___2000 International Energy Conservation Code (2000 IECC)
    ___92 Model Energy Code (92 MEC)
    ___Unknown
    ___Other _____

12. What is the name of the company that built your home?

    _____

    ___Unknown

Example E.4. Energy Audit Authorization Form

The purpose of the walk-through energy audit and ISU energy study has been explained to me by the ISU Research Team. By signing this authorization form, I am giving my permission for the ISU Research Team to conduct an energy audit of my home while in my presence. This permission is granted only for the time period of _____ to _____ on the date of _____.

_____

(Print First and Last Name)

_____ _____

(Signature) (Today's Date)

Example E.5. Authorization for Access to Energy Information

By signing this authorization form, I am giving my permission to Jeremy Cloutier from the ISU Research Team to obtain copies of my monthly energy bills for the years 2002 and 2003. It is in my understanding that this energy data will be used for the ISU energy study, but my name and home address will be kept anonymous.

Name:
Street Address:
City, State Zip:
Home Phone: Work Phone:

Type of service (Natural Gas / Oil / Electricity / Propane) please circle only one

Utility Company Name:
_____

Account Number:
_____

Meter Number:
_____

_____

_____
(Print First and Last Name)

_____ _____
(Signature) (Today's Date)

Example E.6. Energy Audit Form

Name of Homeowner: _____

Street Address: _____

City: _____

County: _____

Referred By: _____

Time Start: _____ Finish: _____ Total: _____

I. Basement

A. Size

1. Floor surface area? _____
2. Ceiling height? _____

B. Heating System

1. Manufacturer, model, year of furnace/boiler?

_____

2. The seams of the furnace/boiler ducts are (Taped / Sealed)?

___Other _____

II. First Floor

A. Size

1. Floor surface area? _____
2. Ceiling height? _____

B. Ventilation

1. Return Ducts
   a) Location (Ceiling / Floor)
   b) Condition (1 2 3 4 5)
2. Supply Ducts
   a) Location (Ceiling / Floor)
   b) Condition (1 2 3 4 5)
3. Are the supply or return ducts blocked by furniture, rugs, drapes, etc? (1 2 3 4 5)

C. Windows
   1. North
      a) Coverings (Blinds / Drapes / Nothing)
      b) Air leakage (1 2 3 4 5)
      c) Total area? _____

   2. South
      a) Coverings (Blinds / Drapes / Nothing)
      b) Air leakage (1 2 3 4 5)
      c) Total area? _____

   3. East
      a) Coverings (Blinds / Drapes / Nothing)
      b) Air leakage (1 2 3 4 5)
      c) Total area? _____

   4. West
      a) Coverings (Blinds / Drapes / Nothing)
      b) Air leakage (1 2 3 4 5)
      c) Total area? _____

D. Room Characteristics
   1. Location: _____
      a) Lighting (fluorescent / incandescent / other)
      b) Floor (rugs / carpet) _____% covered
      c) Walls (light / medium / dark)
      d) Ceiling (light / medium / dark)
      e) Ceiling fan (Yes / No)

   2. Location: _____
      a) Lighting (fluorescent / incandescent / other)
      b) Floor (rugs / carpet) _____% covered
      c) Walls (light / medium / dark)
      d) Ceiling (light / medium / dark)
      e) Ceiling fan (Yes / No)

   3. Location: _____
      a) Lighting (fluorescent / incandescent / other)
      b) Floor (rugs / carpet) _____% covered
      c) Walls (light / medium / dark)
      d) Ceiling (light / medium / dark)
      e) Ceiling fan (Yes / No)

   4. Location: _____
      a) Lighting (fluorescent / incandescent / other)
      b) Floor (rugs / carpet) _____% covered
      c) Walls (light / medium / dark)
      d) Ceiling (light / medium / dark)
      e) Ceiling fan (Yes / No)

   5. Location: _____
      a) Lighting (fluorescent / incandescent / other)
      b) Floor (rugs / carpet) _____% covered
      c) Walls (light / medium / dark)
      d) Ceiling (light / medium / dark)
      e) Ceiling fan (Yes / No)

E. Doors
   1. Front
      a) Type
         ___Air lock entry hall
         ___Double door
         ___Insulated storm door
         ___Other _____
      b) Amount of air leakage (1 2 3 4 5)

   2. Back
      a) Type
         ___Air lock entry hall
         ___Double door
         ___Insulated storm door
         ___Other _____
      b) Amount of air leakage (1 2 3 4 5)

   3. Other _____
      a) Type
         ___Air lock entry hall
         ___Double door
         ___Insulated storm door
         ___Other _____
      b) Amount of air leakage (1 2 3 4 5)

F. Fireplace

   Is there a fireplace?
   ___Yes Does it have glass doors? ___Yes ___No
   ___No

G. Bathroom
   1. Is there evidence of moisture? (Yes / No)
   2. Is there an exhaust fan? (Yes / No)

H. Temperature Control
   1. Thermostat
      a) Temperature _____

      b) Location _____
      c) Type (Manual / Programmable)
         ___ Other _____

   2. Is there a humidifier? (Yes / No)

III. Second Floor
A. Size
   1. Floor surface area? _____

   2. Ceiling height? _____

B. Ventilation
   1. Return Ducts
      a) Location (Ceiling / Floor)
      b) Condition (1 2 3 4 5)

2. Supply Ducts
    a) Location (Ceiling / Floor)
    b) Condition (1 2 3 4 5)

3. Are the supply or return ducts blocked by furniture, rugs, drapes, etc? (1 2 3 4 5)

C. Windows
1. North
    a) Coverings (Blinds / Drapes / Nothing)
    b) Air leakage (1 2 3 4 5)
    c) Total area? _____

2. South
    a) Coverings (Blinds / Drapes / Nothing)
    b) Air leakage (1 2 3 4 5)
    c) Total area? _____

3. East
    a) Coverings (Blinds / Drapes / Nothing)
    b) Air leakage (1 2 3 4 5)
    c) Total area? _____

4. West
    a) Coverings (Blinds / Drapes / Nothing)
    b) Air leakage (1 2 3 4 5)
    c) Total area? _____

D. Room Characteristics
1. Location: _____
    a) Lighting (fluorescent / incandescent / other)
    b) Floor (rugs / carpet) _____% covered
    c) Walls (light / medium / dark)
    d) Ceiling (light / medium / dark)
    e) Ceiling fan (Yes / No)

2. Location: _____
    a) Lighting (fluorescent / incandescent / other)
    b) Floor (rugs / carpet) _____% covered
    c) Walls (light / medium / dark)
    d) Ceiling (light / medium / dark)
    e) Ceiling fan (Yes / No)

3. Location: _____
    a) Lighting (fluorescent / incandescent / other)
    b) Floor (rugs / carpet) _____% covered
    c) Walls (light / medium / dark)
    d) Ceiling (light / medium / dark)
    e) Ceiling fan (Yes / No)

4. Location: _____
    a) Lighting (fluorescent / incandescent / other)
    b) Floor (rugs / carpet) _____% covered
    c) Walls (light / medium / dark)
    d) Ceiling (light / medium / dark)
    e) Ceiling fan (Yes / No)

E. Bathroom

1. Is there evidence of moisture? (Yes / No)

2. Is there an exhaust fan? (Yes / No)

IV. Attic

A. Size

1. Floor surface area? _____

2. Ceiling height? _____

B. Insulation

1. Is there insulation? (Yes / No)

2. Type

___Blanket
___Blown
___N/A
___Other _____

C. Infiltration

Are there air leaks, broken windows, rotted boards, or other sources of cold air leaks into the attic?
___Yes
___No
Comments _____

V. Outside

A. Cooling System

Manufacturer, model, year of air conditioner?

_____

B. Infiltration

1. Are there spaces for air leaks between the house and its foundation, broken windows, rotted boards or other sources of cold air leaks into the cellar or crawl space?
___Yes
___No

2. Are cracks and joints around windows, doors, stairways, pipes, and electrical wires caulked?
___Yes
___No

3. Is there weather stripping around the inner and outer doors?
___Yes
___No

4. Is there weather stripping around the windows?
___Yes
___No

5. Are cracks in walls and foundations sealed and holes plugged in?
___Yes
___No

C. Windows

Are there overhangs over the windows?

North (Yes / No)
South (Yes / No)
East (Yes / No)
West (Yes / No)

D. Outside Characteristics

1. Is there a garage attached to the house?
   ___Yes Which side? (N / S / E / W)
   ___No

2. Digital Pictures
   Number(s) _____ Location of interest (N / S / E / W)

   _____

   _____

   Number(s) _____ Location of interest (N / S / E / W)

   _____

   _____

   Number(s) _____ Location of interest (N / S / E / W)

   _____

   _____

   Number(s) _____ Location of interest (N / S / E / W)

   _____

   _____

   Number(s) _____ Location of interest (N / S / E / W)

   _____

   _____

VI. Questions to ask the homeowner

A. HVAC System

1. Last time filter was changed? _____

2. How often is the filter changed?_____

3. Last time air-conditioner coil was cleaned? _____

4. How often is the air-conditioner coil cleaned?_____

B. Other

_____

_____

VII. Annotations

5 = high energy efficiency
3 = average energy efficiency
1 = low energy efficiency